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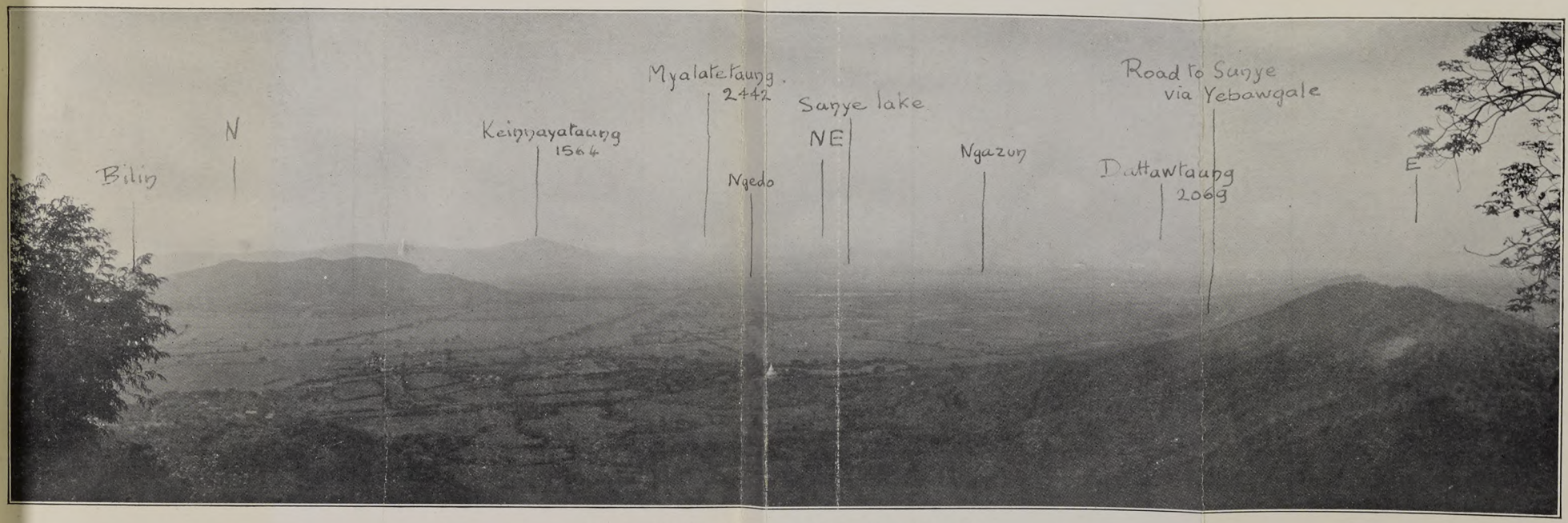

Photo No. 1.—View from Top of Kyaukse Hill.

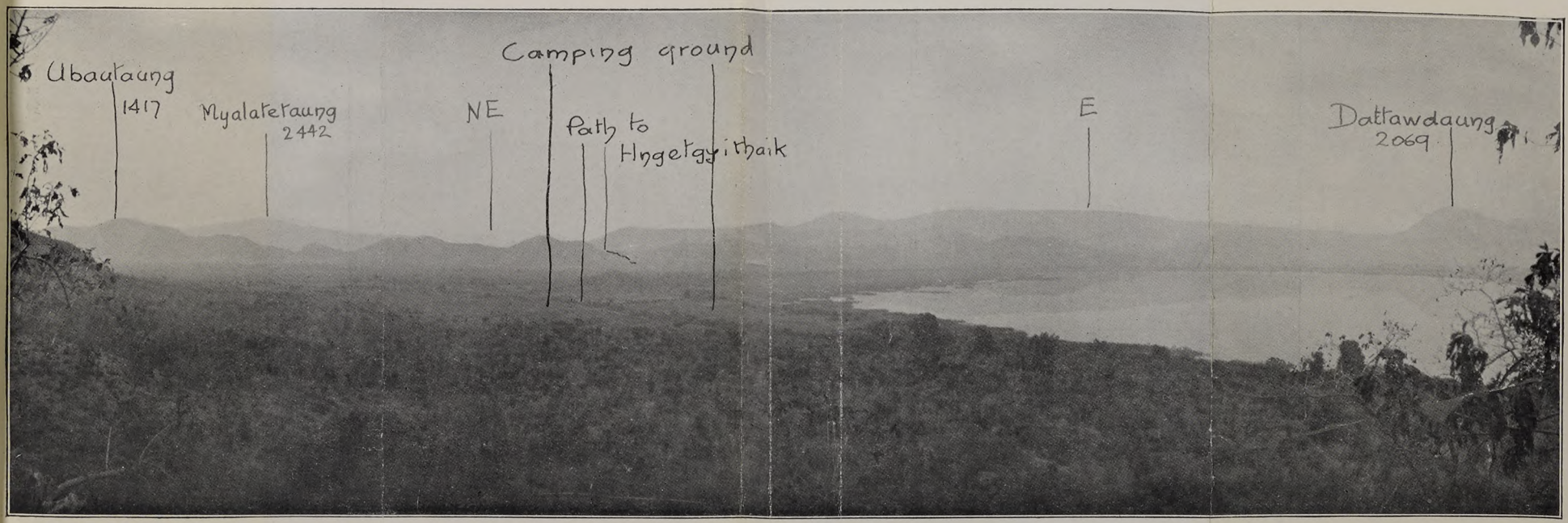

Photo No. 2.—Sunye Lake and Camping Ground.

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ENGINEER RECONNAISSANCE IN UPPER BURMA.

By D.F.

LIEUT.-COLONEL SKEY in his interesting article in the *R.E. Journal* for November, 1908, suggested the practice in peace time of Engineer reconnaissances. Several such had already been undertaken in the neighbourhood of Mandalay by small parties of No. 15 (Burma) Company, 2nd "Q.O." Sappers and Miners, and it is thought that some account of these may be of interest.

Mandalay lies on the left bank of the River Irrawaddy in a plain varying from 12 to 20 miles in width between that river and the Shan Mountains. This plain is irrigated and mostly under rice cultivation : the western slopes of the Shan Hills which rise to 4,000′ and 5,000′ are steep and covered with dense jungle but on top is an inhabited plateau cultivated to a certain extent. The main railway line to Rangoon runs due south from Mandalay while to the east the Northern Shan States line to Maymyo, on the tableland referred to above, is continued to Lashio 100 miles from the Chinese frontier. Roughly parallel to this railway at distances varying from 4 to 30 miles flows the Myitngé, or Namtu, which joins the Irrawaddy at Ava 10 miles south of Mandalay, and with its tributaries governs the configuration of the mountain masses above mentioned.

These reconnaissances were usually carried out by a couple of officers, British and Burman, and three or four N.C.O.'s with a few pack mules. Each was based on a general idea and in every case a definite task was assigned to the party. Thus one was carried out from September 21st to 24th, 1908, on the assumption that Mandalay and Maymyo were occupied by opposing forces and the special mission of the party was to report on a route leading from Madaya (a small town 15 miles north of Mandalay) up the hills to the east and into Maymyo from the north. Work necessary to render the path suitable for a brigade with pack transport was to be noted.

On all these tours the work was distributed by allotting in turn to the various members of the party projects for the design of bridges, swamp crossings, etc., to be worked out with hand sketches and table of tools and working parties. A printed form was used for this.

In the above case, from Madaya to the foot of the hills a

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number of small bridges and two or three crossings over swamps were required. Regrading was found to be necessary in several places on the ascent, and on the plateau some small bridges were wanted. This reconnaissance was carried out in three days, the party returning from Maymyo by train on the fourth day.

The object of another tour was to reconnoitre a route from Maymyo to the Myitngé River 20 miles to the south, and thence proceed by boat to the railway bridge by which the main line to Rangoon crosses that river, and prepare a project for its demolition with a view to cutting the communications of an enemy supposed to be holding Mandalay. The river however was found to be in flood and only navigable by bamboo rafts which required three or four days to prepare: so the party returned to Maymyo the way they came.

On another occasion the general idea was that a force invading Burma from the north-east had reached Maymyo; and the party starting from Madaya was to cut the Maymyo-Lashio railway near Hsumhsai Station 20 miles east of Maymyo where the line crosses several streams; and the route followed was to be reported on with a view to future use.

The following is a more detailed account of a reconnaissance carried out in March, 1909. On this occasion photos were taken to illustrate the report, a 12″ × 10″ stand camera and a 12″ × 4″ Kodak Panoram being used for the purpose.

The object was to reconnoitre a route between Kyaukse, a town 24 miles south of Mandalay on the Rangoon line (see map) and Maymyo so as to establish communication between a force coming up to Kyaukse from Rangoon and another at Maymyo, Mandalay being supposed in the possession of an enemy. The best route appeared to be *viâ* the Sunye Lake connecting and the Myitngé Valley connecting at Kywetnapa with the Mandalay-Maymyo main road *vide* map; this would be screened for the most part from Mandalay by the hills between Belin and the Myalate-taung.

The party consisted of:—Capt. D. Forster, R.E., Serjt. T. Cooper, R.E. (photographer), Naik Maung Po Thai, Lance-Naik Maung Myat Bwin, 2 sappers, 2 muleteers and 6 mules.

On the 25th of March the party left Mandalay by the 2 p.m. train for Kyaukse whither the mules had already proceeded. The same afternoon a photo of the country to the north-east was taken from the top of Kyaukse Hill (*Photo* No. 1).

The next morning the party marched to Sunye 10 miles distant across a level plain mostly under rice cultivation. The only work that day beyond a report on the road consisted in the selection of a camping ground suitable for any force up to a brigade, and in working out arrangements for water supply from Sunye Lake.

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Photos were taken showing camping ground and the direction of next day's march (*Photo* No. 2). From Sunye the route led round the north end of the lake and thence over a series of rocky hills covered for the most part with bamboo jungle (*Photo* 3); the

Photo No. 3.—Highest Point on Sunye—Hngetgyithaik Path.

highest col crossed was about 1,100′ and distant 7 miles from Sunye: from there the path led down in 3½ miles to the valley of the Myitngé, a clear cool stream 80 yards wide. The party ferried over, swimming the mules, and halted at Hngetgyithaik, a hamlet on the opposite bank, and in the afternoon got out projects for a brigade camping ground and for a flying bridge over the Myitngé with approaches, landing stages, etc. (*Photo* No. 4).

On the 27th the party divided, some going down the river by country boat to Kyetnapa, and the others with the mules following the path along the right bank to the same place. Capt. Forster and a sapper ascended the Myalate-taung (which rises precipitously on the left bank of the Myitngé) with a view to reporting on its suitability as a signal station. Projects were got out for some minor bridging on the path and for a camping ground at Kyetnapa.

Next day the party marched to Tonbo, arranged for the demolition of road and railway bridges over the Nadaungchachaung,

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a stream a mile east of Tonbo Station, and returned to Mandalay by train.

The weather throughout had been hot and misty and, in consequence, the photos were not as clear as they might have been. The 12″ × 10″ camera was not of much use; the best photos from a military point of view being taken with the 12″ × 4″ Panoram. On this tour the marches were shorter than on previous occasions and all work was finished up and corrected the same day.

In all these reconnaissances the conditions were almost ideal, as the ground traversed was for the most part new to all concerned and many of the paths followed were little known or used by anybody. The interest was further enhanced by the variety of terrain met with, steep mountains and level plains, open tableland and jungle-covered valley, while minor details were not wanting such as lakes, rivers, streams, canals, roads and railways.

There is no doubt that all ranks may learn a good deal from such tours which are also very enjoyable, especially in a fascinating country like Upper Burma.

Photo No. 4.—R. Myitngé at Hngetgyithaik.—Proposed Site for Flying Bridge.

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THE EMPLOYMENT OF ROYAL ENGINEERS ON MANŒUVRES.

THE following extracts from the diaries of the R.E. officers engaged in the recent manœuvres, have been kindly communicated by the I. of R.E. Giving as they do, a good idea of the work now done by the Engineers in manœuvres they are sure to prove of great interest to readers of the *R.E. Journal.*

. . . .

EXTRACTS FROM DIARY OF C.R.E., 3RD DIVISION.

SECOND DAY.

September 7th.—General and Special Idea.—(Appendix 11).

Operation Orders by G.O.C. Red received at 7.30 p.m. on 6th September.—(Appendix 12).

8.15 a.m.—Reconnoitred position with G.O.C. Red who directed R.E. to clear ground on right flank over which he anticipated that he would have to deliver his counter-attack.

9.30 a.m.—Issued Operation Order No. 9.—(Appendix 13).

11.15 a.m.—The G.O.C. being anxious to obtain information regarding enemy in front of our right flank which he thought they might be turning, I offered to send a well-mounted officer to reconnoitre.

Issued Operation Order No. 10.—(Appendix 14).

11.50 a.m.—Issued Operation Order No. 11.—(Appendix 15).

12 noon.—Seeing the enemy appear in strength on the right of our position, and commence firing on our reserve in the hollow in rear of the centre of our position, I took the 2 companies to Racedown to construct fire trenches to cover retreat which appeared to be imminent. The position was about 2,000 yards from enemy and as they were already engaged with our reserve, and were being taken in flank by our local reserves from point 401, we should not have been seen digging. We could have partly constructed two fire trenches each 40 or 50 yards long with an excellent field of fire.

12.25 p.m.—"Cease Fire" sounded.

Day fine and cool. Lieut. —— acted as Adjutant.

THIRD DAY.

September 9th.—General and Special Ideas.

I went out as C.R.E. Red Force. Lieut. —— acted as Adjutant.

56th Company Red. 57th Company Blue Force.

9.30 a.m.—Moved off from Hill Farm with G.O.C.

10.21 a.m.—Lieut. —— took down a copy of Operation Order No. 58, dictated by G.O.C.

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10.25 a.m.—G.O.C. pointed out a position W. of the road opposite F. of Fontmell Wood which was to be entrenched by 56th Company, R.E., in case of failure of attack of right column.

10.40 a.m.—Pointed out site to Major ——.

10.55 a.m.—56th Company started to work.

11.10 a.m.—Showed Major —— Operation Order No. 58.—(Appendix 16).

11.11 a.m.—A Major, Royal Munster Fusiliers, came by order of G.O.C. to ask whether R.E. required any assistance from his battalion which was in reserve near cross roads N. of Sutton Hill. I asked for 1 company to prolong our trench to the left, and directed Major —— to point out site to O.C. Company on his arrival. I then returned to Headquarters of G.O.C.

11.50 a.m.—Attack being checked and counter-attack imminent, I was ordered to reconnoitre and entrench a position on right rear of trench now being constructed, so as to cover an eventual retirement from it.

12.20 p.m.—Selected and pointed out to Major —— site for a ½ company trench in a stubble field at W. of Fontmell Wood and directed other ½ company to prepare for defence the bank and hedge for 80 yards E. of cross roads at Hill Farm. Asked O.C. Royal Munster Fusiliers to send 1 company to help Major —— with the trench.

2.32 p.m.—Sent Lieut. —— to tell Major —— to retire as far as the wood at Sutton Hill road junction, as the evening's attack was now developing against our right column.

2.55 p.m.—"Cease Fire" sounded.

Notes.—Day fine and cool.

The necessity of infantry assistance in constructing fire trenches was clearly brought out.

FOURTH DAY.

September 10th.—General and Special Ideas.—(Appendix 18).

Operation Order No. 55 by G.O.C. Red.—(Appendix 19).

The above were received overnight.

12.40 p.m.—I took down Operation Order No. 59.—(Appendix 20).

12.45 p.m.—By direction of G.O.C. I issued Order No. 12.—(Appendix 21).

1.20 p.m.—Discovering that the 56th Company was already at Sutton Waldren, I sent in Order No. 13.—(Appendix 22).

1.30 p.m.—Sent extract from G.O.C.'s Operation Order 59 to O.C. 56th Company to explain my Order No. 12 and ordered Major —— to take command of the 2 companies and get his orders from G.O.C. 8th Brigade.

I gave necessary orders to the same effect verbally to O C. 57th Company and directed him to send an officer to Major —— for orders.

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Both companies followed the attack carrying entrenching tools, leaving their carts in Sutton Waldren.

3.20 p.m.—"Cease Fire" sounded.

Notes.—Day fine and cool.

Adjutant, Lieut. ——.

APPENDIX 13.

Operation Order No. 9. *B. in British Settlement.*

O.'s C. 56th and 57th Companies.

Cut gaps in the hedges pointed out to you to facilitate the counter-attack.

Given verbally to O.'s C. 56th and 57th Companies at 9.30 a.m.

APPENDIX 14.

Operation Order No. 10. *Point* 401.

Proceed in the direction of Tarrant Hinton, pushing forward towards Tarrant Gunville and ascertain what you can of the movements of the enemy. Keep your orderly ¼ mile behind you to warn me if you are captured.

Given verbally to Lieut. ——, R.E., at 11.25 a.m.

APPENDIX 15.

Operation Order No. 11. *Point* 401.

Reassemble your companies at the spot pointed out to you and hold yourselves in readiness to accompany the counter-attack with your cutting tools.

Given verbally by Lieut. ——, R.E., to O.'s C. 56th and 57th Companies at 11.15 a.m.

APPENDIX 21.

Operation Order No. 12. *Point* 356 *W. of Sutton Waldren.*

O.C. 56th Company, R.E.

Both R.E. companies will assemble in field N.W. of farm at road junction just S. of Point 356 and be in readiness to follow the attack of centre column.

12.45 p.m.—By orderly to O.C. 57th Company. Verbally by Lieut. —— to O.C. 56th Company, R.E.

APPENDIX 22.

Operation Order No. 13. *Point* 356 *W. of Sutton Waldren.*

O.C. 56th Company, R.E.

Stay where this finds you, I will acquaint you shortly with the dispositions for the attack.

1.20 p.m.

EXTRACTS FROM DIARY OF C.R.E., 1ST DIVISION.

September 6th, 1910.—Joined Headquarters, 1st Division, at Bishop-Sutton Camp near New Alresford.

September 7th.—Marched to camp at Bossington Farm 1 mile S. of Houghton.

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September 8th.—Received orders to reconnoitre River Test near Longstock House for position for pontoon bridge in case it should be required.

Report and sketch attached "A."

One copy given to G.S.O. in case I might not be with G.O.C. when required.

Left at 6.30 a.m. and rejoined 1st Division Headquarters at camp near Oldsarum at 4 p.m.

September 9th.—Left camp with G.O.C. at 2.30 a.m., reached Newfarm at 5 a.m. arrangements made for water supply.

Left Newfarm at 6 a.m. and went to left flank as directed by G.O.C. with Capt. ——as orderly officer, and 2 orderlies to reconnoitre near Cleave Hill near Longstock for approach of enemy's cavalry—about 8.30 had to retire on approach of enemy's patrols and rejoined G.O.C. at Upper Sandydown Farm 1 mile E. by N. of Stockbridge.

23rd (Field) Company prepared position at Woodbury Ring since its capture by A.G.

About 12.30 p.m. I ordered it to send ½ company to join 1st Brigade and other ½ company to join main body of 2nd Brigade.

I also ordered 26th (Field) Company to push on towards Sutton Scotney.

About 1 p.m. men of 1st Telegraph Company were ordered to repel sudden attack of enemy along Roman Road at Hill Farm.

About 2 p.m. I proposed to G.O.C. to push on to Sutton Scotney to reconnoitre defensive position for night outpost line E. and S. of village. Sketch attached "B." After reconnoitring Redhouse on E. was nearly captured about 3 p.m. After counter-attack had been made by 1st Brigade to N.E. about 5 p.m. G.O.C. reported cavalry was attacking from N. along Bullington Road.

I took out 26th Company already in position—½ 23rd Company and 1st Telegraph Company to repel the attack which was done successfully just before "Stand Fast" sounded.

September 10th.—Marched at 9.15 a.m. with G.O.C., about 10 a.m. I went to front to see if any work was required for attacking troops, found ½ 26th Company already at Micheldever Station repairing bridge which had been destroyed, 1½ hours to repair.

On arrival of ½ 23rd Company, I sent it to make level crossing at railway station which would take less time than repairing bridge and sent ½ 26th Company to join remainder which I had ordered forward to tunnel under main road. Pushed on to reconnoitre right front and ordered up 26th Company to defend West and Popham Farms with approval of Brigadier, 1st Brigade, who was just pushing forward attack towards Dunmer.

This would have been most useful in case of counter-attack on right flank. I then proceeded to left front, but found no employment for R.E. although 3rd Brigade had been checked since about 1 p.m.

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September 12th.—On my suggestion a R.E. officer, Lieut. ——, was detailed as one of the five officers to reconnoitre the five roads to the front, leaving camp at 2.30 p.m. and in spite of several narrow escapes of being captured (his orderly was taken) carried out his duties. Report attached.

At 11 p.m. commenced night march—1 company being with the A.G. of each column.

September 13th.—Owing to the turning of enemy's left flank and rapid driving in of his troops by 1st Division no use was found for R.E. companies till "Stand Fast" sounded about 8.30 p.m.

REPORT ON PROPOSED PONTOON BRIDGE AT LONGSTOCK HOUSE.

(1). In order to protect construction of bridge, it would be necessary to first occupy wood "A."

(2). Wood E is out of bounds—but would form good starting point.

(3). There are 2 16′ punts at B and C capable of holding 6 men each. If no means of ferrying men could wade at B weir 2′ deep at C 3′ to 4′ hard bottom.

(4). (*a*). Bridge at C could be made from bridging equipment of 2 field companies.

(*b*). If approach is made through wood E, as it should be, it would take 1½ hours for 1 company to make approach road.

(*c*). If made at night after A is held, no approach road is necessary along hedge of E, but B is preferable.

(5). After position is occupied there is a fair road for artillery and wheeled traffic along cart track 100 yards N. of A and railway can be crossed with little labour if bridge is destroyed.

One ditch 15′ wide next to river could be filled with felled timber from E.

(6). The meadows on E. bank are generally heavy, and intersected with small drainage channels.

(7).—The bridge could be constructed by 1 field company in 1¼ hours by day, and 2 hours by night.

56TH COMPANY, R.E.

Extracts from Manœuvre Diary, 1910.

September 6th, 1910.—7.20 a.m. (Iwerne Minster).—Paraded and marched to rendezvous at Ralston.

8.40 a.m. (Ralston).—Received orders from C.R.E. to march with 1 K.R.R. to Hambledon Hill and to help place it in a state of defence. Marched to top of Hambledon Hill and prepared S. end of camp for defence. (Theoretical only). Vehicles to Child Okeford.

12 noon (Hambledon Hill).—Received orders from C.R.E. to send parties to prepare Hayward Bridge and bridge at Hammoon for demolition. Sent Lieut. —— to Hammoon and 2nd Lieut. —— to Hayward Bridge with Nos. 3 and 4 Squads.—(Attached).

12.5 p.m. (Hambledon Hill).—These parties moved off.

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1.20 p.m. (Hambledon Hill).—Received orders from C.R.E. to move to road junction near P. of Fontmell Parva.

1.50 p.m. (Child Okeford).—Arrived at Child Okeford.

Ordered Lieut. —— with 1 and 2 Squads to march to road junction near Fontmell Parva *viâ* cross roads at first D. of Child Okeford. Rode to Hayward Bridge and found it prepared for demolition and party preparing to march to Fontmell Parva.

2.30 p.m. (Fontmell Parva).—Arrived.

3 p.m. (Fontmell Parva).—Marched back to camp.

4.15 p.m. (Iwerne Minster).—Arrived in camp.

5.30 p.m. (Iwerne Minster).—Paraded and marched to Pimperne.

7.30 p.m. (Pimperne).—Bivouacked for the night.

September 7th, 1910.—8 a.m. (Pimperne).—Paraded. Marched to defensive position near Langton Lodge.

8.40 a.m. (British Settlement).—Arrived.

9.14 a.m. (British Settlement).—Received orders from C.R.E. to proceed to near Point 401.

9.25 a.m. (300 yards N.E. of Point 401).—Arrived.

Employed on clearing hedges in line of probable advance of counter-attack. (Theoretical only).

11.15 a.m. (300 yards N.E. of Point 401).—Received orders from C.R.E. to proceed about 800 yards S.S.W. and prepare a line of defence facing S.W.

12.25 p.m. (800 yards N.E. of Point 401).—Just commencing to work when "Stand Fast" sounded.

12.30 p.m. (800 yards S.E. of Point 401).—Marched off.

2.55 p.m. (Iwerne Minster).—Arrived in camp.

September 12th, 1910.—6.30 p.m.—G.O.C. 9th Brigade arrived.

6.35 p.m.—Started with him to reconnoitre for bridge.

7 p.m. (R. Stour due S. of 2nd A. of Hayward Bridge).—This position approved by G.O.C. 9th Brigade.

7.15 p.m. (bivouac near Child Okeford).—O.C. Company issued orders for teams for pontoon wagons and for men to parade at once. Trestle wagon with civilian horses arrived.

7.20 p.m.—Marched.

8.45 p.m.—Arrived near site of bridge, having been delayed by transport of other units in Child Okeford, and commenced to unload bridging material off wagons and to carry it to river, a distance of about 350 yards, the wagons not being able to get nearer on account of marshy ground.

9 p.m.—Commenced construction of bridge, a party being detailed to continue carrying down material. Banks of river 6′ high. Gap 66′ in clear. 2 Weldon trestles and 2 pontoons used. Shore transom sunk 2′ 6″ in banks, about 4′ 6″ from edge. Ramps made.

9.20 p.m.—Knocked off for teas.

10 p.m.—Resumed work.

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10.30 p.m.—1 officer and 24 men of 1/K.R.R. arrived to make approach for transport over marshy ground.

12. m.n.—1 officer and 60 men of 1/K.R.R. arrived to dig ramps at each end of bridge.

September 13th, 1910.—1.50 a.m.—Bridge ready for infantry.

2 a.m.—9th Brigade commenced to cross.

2.40 a.m.—Infantry (3 battalions 9th and 2 battalions 8th Brigades) finished crossing.

4.15 a.m.—Bridge ready for artillery and transport.

5.45 a.m. (bivouac near Child Okeford).—Company arrived back in bivouac leaving 1 officer, 1 N.C.O. and 2 men at bridge.

57TH COMPANY, R.E.

Extracts from Manœuvre Diary, 1910.

September 9th.—5.30 a.m.—Breakfast.

6.15 a.m.—Marching order. Marched in rear of 8th Brigade, as part of Blue Force, taking 2 sections complete, and no bridging wagons. 56th Company were with "Red" Force.

6.55 a.m.—*Vide* Special Idea, attached, reached Point 784. I accompanied G.O.C. Blue to reconnoitre positions, arriving at Point 784 myself at 7.45 a.m.

By order of the G.O.C., entrenched 250 yards of position to command valley R. Range-Melbury Down. These trenches were for use of infantry if required. Selected site and ordered ½ company under Lieut. —— to entrench it.

8.55 a.m.—Ordered ¼ company under Lieut. —— to construct wire entanglements across col N. of Point 784. Lieut. —— plan was to collect poles from spars near site and to cut others from wood N. of Melbury Hill and to collect wire from neighbouring farms and send it up in farm carts. Calculated could have made belt 3 yards deep in 3 hours; but only 1¼ hours were available as enemy's scouts arrived 10.30. Considered the task was half done and better than nothing.

11.5 a.m.—Went to E. slopes of Melbury Hill and both ½ companies arrived there in face of enemy's strong attack. Had previously sent wagons to inn in Melbury Abbas. Now sent them by flag signal to cross roads N. of Melbury Hill to be safe.

12.10 p.m.—Reinforcements arrived, general advance on both flanks.

12.20 p.m.—Accompanied advance towards Point 784.

1.30 p.m.—Strong counter-attack on our extreme left. Occupied our trenches and helped to beat it off. Sent wagons, by flag signal to Compton Abbas.

1.50 p.m.—Continued advance, and now W. of Core Farm.

2.55 p.m.—Took part in assault on enemy's position W. of Fontmell Wood.

3 p.m.—"Cease Fire" sounded.

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Company reached camp 4.10 p.m. Dinner on return. No casualties.

Weather beautifully fine all day.

September 16th.—3 a.m.—Received orders to put Maperton and North Cheriton in state of defence, commencing 7 a.m.

4 a.m.—Reveille.

5.15 a.m.—Breakfast.

5.50 a.m.—Received instructions to move at once.

6.5 a.m.—Moved on North Cheriton, leaving 2nd Lieut. —— to take charge of pontoons and 2nd line transport. These ordered to park S. of Charlton Horethorne.

6.15 a.m.—Sent Lieuts. —— and —— to reconnoitre possibilities of defence of Maperton and North Cheriton respectively. Sent 2nd Lieut. —— with Lieut. ——.

6.50 a.m.—Reached North Cheriton. Left left-half company at Lieut. —— disposal, and advanced on Maperton.

7.10 a.m.—Arrived Maperton. Inspected Lieut. —— proposals for defence, and left him right-half company to proceed with the work.

7.50 a.m.—Back at North Cheriton. Lieut. —— gone as Adjutant to C.R.E. 2nd Lieut. —— in charge. Inspected his work and proposals. Work of defence now proceeding in both villages.

These villages form part of line of defence.

Operation Order No. 4 by G.O.C.

Note.—Weather fine but cold. Men had had no breakfast, as rations were not drawn last night.

Rations drawn in the morning at 6 a.m.

8.55 a.m.—Defence preparations of North Cheriton.

Left 2nd Lieut. —— in charge, went to Maperton.

9.15 a.m.—Found Lieut. —— preparations complete, left him and ½ company there and went to Maperton.

9.40 a.m.—Artillery duel opened.

9.45 a.m.—Returned to North Cheriton.

Found preparations complete and ½ company held in reserve by Colonel to aid in defence if required.

1.10 p.m.—Both ½ companies as before.

Received Operation Order 5, and C.R.E.'s Operation Order 1. I informed C.R.E. that I should remain as I was, unless I received further instructions.

2.30 p.m.—Strong attack by enemy. R.E. assist to repel it.

3.30 p.m.—Enemy assault. Attack judged to fail. We reoccupy our trenches.

3.50 p.m. "Cease Fire" sounded. The right-half company under Lieut. —— had gone forward to aid the attack of the 8th Brigade.

5.30 p.m.—Arrived bivouac at North Cadbury.

Put down pumps and troughs.

9 p.m.—Dinners. Breakfast rations extra.

Weather—fine and bright.

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RESISTANCE AND "DRIFT" OF A BULLET.

By LIEUT.-COLONEL R. DE VILLAMIL, LATE R.E.

EVERY soldier, and more especially every Royal Engineer, must have thought about the resistance the air offers to a bullet, and must also have wondered why the bullet should be deflected to the right or left according as the rifling is right or left-handed. Textbooks state certain facts but do not appear to attempt to explain them. I thought therefore that a little light on the subject might not be unacceptable to the readers of the *Royal Engineers Journal.*

To take the resistance first: Professor Perry in his *Applied Mechanics* gives the facts as:—"Roughly we may take it that resistance is generally proportional to square of speed. In the case of shot this law holds, probably up to speeds of 300′ per second: from 400 to 1,000′ per second the resistance is possibly proportional to the $2\frac{1}{2}$ power of the speed. Beyond 1,100′ per second we may take, F being in pounds, d the diameter of a shot in feet, v the velocity in feet per second, $F = fd^2 (v - 800)$, where $f = 3$ for spherical and 2 for the elongated shot with ogee-shaped heads. The velocity is greater than that of sound, and probably it is to this that the change of law is due."

This statement of *facts* is exceedingly clear and precise, but explanation, of the why and the wherefore, there is none; a suggestion is indeed thrown out at the end that the sudden change of law at about 1,100′ per second is due to the velocity being in excess of that of sound. What is the law, however, which "changes" and why does it apparently change *twice?*

Professor Perry's statement that resistance is *generally* "proportional to square of speed" is not quite satisfying—more especially as he says later that a shot does not follow this law, except at very low velocity. Let us examine the subject more closely and see what is the true law of the resistance, and, if the law changes, *why it changes.*

Air is a compressible fluid. As this compression leads to complications it will be simpler to first examine the resistance in a non-compressible fluid, like water, and then, later, see how the elasticity modifies this result. A bullet, or a torpedo, moving in water meets with two forms of resistance, 1st that due to friction, and 2nd that due to the formation of eddies, or what is sometimes called "sinuous motion." These are the only two possible forms of resistance we can imagine.

Friction can only produce what is called "direct" (as opposed to sinuous) motion, and the resistance caused by it *varies as the velocity* only. Sinuous or eddy-forming resistance on the other hand *varies*

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as the square of the velocity. The total resistance may therefore be expressed as :

$$R = AV + BV^2$$

where A and B are constants.

This law applies to *all* forms of liquid resistance. We see that (A being small) when V is not very great the resistance really does appear to vary, *very roughly*, as the square of the velocity. It is always *less* than the square in water, and it is generally given in textbooks as about the 1·83 power of the velocity.

Let us now turn to the elastic fluid air and see what complications arise. As the air is elastic the nose of the bullet compresses it somewhat and this adds a new resistance which does not exist in water. This resistance varies as the *cube of the velocity*, when our formula becomes

$$R = AV + BV^2 + CV^3.$$

As this statement may appear a little startling to some readers who have not thought of the subject, I must, necessarily, produce some evidence in support of it.

The molecules of air (or any other gas) to enable them to comply with Mariotte's law must be endowed with repulsive power which varies inversely as the *cube* of their distances apart. This was well known to the Chevalier Dubuat (Colonel of Engineers of France) more than 100 years ago, and is referred to in his *Hydrodynamique*, Vol. II. A very simple and elegant proof of this is also given in Bayma's *Molecular Mechanics*, which I quote in full, as this book is not well known.

"Let V be a cubic recipient containing n^3 molecules of gas, let d be the distance of the neighbouring molecules, p the pressure sustained by one face of the cube, ω the action of one molecule.

We shall have $V = n^3 d^3$, $p = n^2 \omega$.

Let V′ be another cubic recipient containing the same n^3 molecules, let d' be their distance, p' the pressure sustained by one face of the cube, ω' the action of one molecule : we shall have also

$$V' = n^3 d'^3,\ p' = n^2 \omega'.$$

By Mariotte's law we have

$$V : V' :: p' : p;$$

therefore $$\omega : \omega' :: p : p' :: d'^3 : d^3$$

and consequently, *the actions of neighbouring molecules, within the limits in which Mariotte's law is applicable, are for the same substance inversely proportional to the cubes of the molecular distances.*

It will be obvious that the resistance caused by the bullet compressing the air must vary as the *cube of the velocity.*

It is clear that in the formula

$$R = AV + BV^2 + CV^3$$

the first factor AV will tend to *reduce* the resistance to less than the square; whilst CV^3 will tend to *increase* it beyond the square.

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Between small limits the total resistance will vary *roughly*—not accurately—as the square of the velocity. There is no *change of law* at 300′ or 400′ per second, but as CV^3 increases more rapidly than AV the *total resistance* will increase, pass the square and eventually attain about the $2\frac{1}{2}$ power of the speed—as pointed out by Professor Perry.

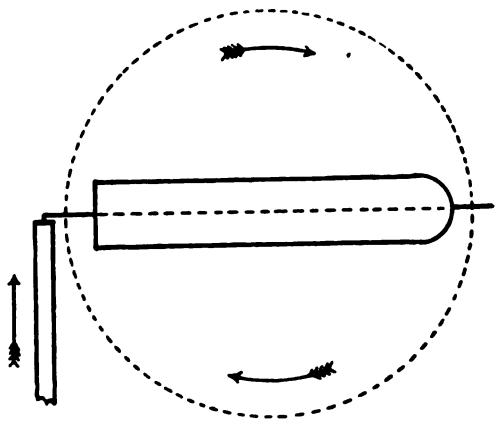
At about the velocity of 1,040′ per second (the velocity of sound) a *sudden* and abrupt change of the law takes place—more correctly, perhaps, "change of resistance," for the *law* is not changed. All the potential energy in the air being exhausted it is no longer capable of *increasing* its sinuous motion, which then becomes *constant;* when BV^2=constant. In the same manner the bullet cannot compress the air in front of it any more, so that CV^3 *also becomes constant.* The formula then becomes

$$R = AV + \text{constant}$$

or the resistance *increases as the velocity* only.

It is obvious that this is another form of Professor Perry's formula, where the resistance *increases as the velocity*—1,000 for each unit of increase of v.

Next, why does a bullet not travel in a vertical plane? Why does it "drift" to the right or left? Many years ago it was taught that the bullet "rolled" on the air. This was certainly not a convincing explanation, more especially as there appeared to be no special reason why the bullet should always select a horizontal plane of air to roll on. It is well known that a golf ball can be made to travel in a curved line (neglecting gravity, of course) and that it can even be caused to move in a curve *upwards*—against gravity. This was denied stoutly some years ago, although Newton was aware of it and gave an explanation. The explanation of the motion of the golf ball will not however apply to that of the bullet. The conditions are quite different and a shot cannot be caused to travel *upwards.*



For reasons which I cannot enter into very fully at present, the bullet is chiefly held up in the air by its rear end—by the vacuum formed there acting as a kind of sucker.

Imagine the bullet rapidly rotating and suspended like a gyrostat, as in the sketch. Since the effect of gravity tends to cause the bullet to rotate about a horizontal axis: and since the bullet is rotating rapidly, it will "precess," or move round a

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vertical axis, which passes through the point of support. If the rotation of the bullet be right-handed the precession will be clockwise (looking down upon it) and if the reverse, then "counter-clockwise."

The solution is simple and interesting and has not, that I am aware of, been previously presented.

P.S.—It was only since writing the above that I became aware that Colonel Duchemin (? Eng. of France) published a book in 1842 stating that the resistance of a bullet might be expressed by the formula

$$R = av^2 + bv^3.$$

I have not been able to see this book—it is not in the libraries of the Royal Society, Royal Institution, R.E. Corps, Army Staff or British Museum—but my authority is A. F. Zahm, PH. D., in the *Philosophical Magazine* for 1901. Zahm conducted experiments on the resistance of bullets and examined the results by the use of Duchemin's formula when he says:—"The curve is steeper than the nearest one of the family $R = av^2$, and more nearly coincides with a curve of the family $R = av^3$; but more nearly still with a curve represented by the equation $R = av^2 + bv^3$, as manifested by Fig. 3, which is the exact graph of the equation

$$R = 0{\cdot}000008v^2 + 0{\cdot}00000049v^3."$$

"Thus the law of resistance so earnestly maintained, early in this century and controverted by nearly all later experimenters seems to be corroborated by the measurements made in this research, as far as they go."

This is a most striking confirmation of the formula given in my paper for Zahm's curve could equally be satisfied by

$$R = cv + \frac{1}{m}(0{\cdot}000008v^2 + 0{\cdot}00000049v^3)$$

when c is a constant and m a small number greater than unity: possibly the values of a and b might have to be altered *very slightly*.

The difference between Duchemin's treatment of the subject and mine appears to be that he plotted his results, and then found an empirical formula which would satisfy the curve; whilst I, on the contrary, started from theory and show that this must be the curve. Duchemin *does not appear* to have given any reasons why this should be the law of resistance—Zahm, certainly, gives none in his paper, either—whilst I have endeavoured to do so, and more especially as regards that part of the equation involving the *cube of the velocity*.

Duchemin's "remarkable book" is called *La loi de la Résistance de l'air sur les Projectiles*. He also published a paper in the *Mémorial de l'Artillerie* entitled *Recherches expérimentales sur les lois de la résistance des fluides* in 1842.

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THE CORPS OF ENGINEERS IN NAPOLEON'S "GRANDE ARMÉE."

By Lt.-Col. G. M. W. Macdonogh, R.E.

Up to late years the student of the Napoleonic Wars has had some difficulty in ascertaining the exact composition and organization of the minor units that made up the French armies, and their methods of supply and command. The information was to be found in the Emperor's very voluminous correspondence, and in that of his marshals, but it was so scattered that much labour was required in order to collect it. The publications issued in recent years by the Historical Section of the French General Staff have gone far to remove these difficulties, and Capt. Lechartier's *Service de l'Arrière* issued a few months ago by that section will be found a veritable mine of information.

The advantages to be gained from the study of the Napoleonic campaigns would, it is thought, be much increased if the student were in possession of a clear idea of the resources that were at the disposal of the Emperor with which to carry out his designs, and it has occurred to the writer that it would be of interest to the readers of the *R.E. Journal* to have a slight sketch of the organization of the French Engineers during the Jena Campaign, when Napoleon reached the zenith of his career. In preparing this sketch full use has been made of Capt. Lechartier's book above referred to, and also of the Memoirs of Baron Fain, who was the Emperor's principal private secretary during the later years of his reign.

A short description is also given of the composition of a corps and of a division, as such a knowledge is necessary in order to understand the organization of the engineer troops.

During the Revolutionary Wars the largest tactical and administrative unit was the division which had an effective strength of about 14,000 men and was provided with troops of all arms. When, however, army corps were formed as permanent units (in 1803) the importance of the division declined and it became a subordinate tactical unit which could not operate alone. Napoleon in a letter to Prince Eugene dated Schoenbrünn, 7th June, 1809, indicated its powers by saying "that a division of 9,000 men can be left isolated without inconvenience for one hour, it will contain the enemy however numerous he may be and will give time to the army to arrive."

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In November, 1806, the strength of the divisions varied from 6,000 to 8,000 men. Most of the infantry regiments had only two battalions present, with an average strength of 1,800 to 2,000 rifles. There was no divisional cavalry at all. The divisional artillery seldom consisted of more than 12 to 14 guns, and in one corps, that of Augereau, only 6 guns were left with each divisional commander, the remainder being taken to form an army corps reserve. There were no engineer troops nor tools with the divisions of any corps except the 7th, and the amount of transport both for supplies and ambulances was very restricted.

The normal composition of a corps was three infantry divisions, and a brigade of cavalry. The organization of the artillery varied not only in every corps, but also from day to day in individual corps. In 1805 the normal organization had been 12 guns with each division and an artillery park without guns with each corps. In 1806, however, corps artillery was to be found in many of the army corps. Some of the marshals adhered rigidly to the normal rule. Thus Lannes commenced the 1806 campaign with 12 guns allotted to each of his two divisions and none in reserve, and when in January, 1807, he was given 12 additional pieces he divided them equally between the divisions. Davout on the other hand had, on the 1st October, 1806, only 8 guns with each of his three divisions and kept 12 guns in reserve with the park. The guns captured from the Prussians at Jena and Auerstadt were either divided amongst the divisions or held in reserve at the discretion of the corps commanders. In some corps guns were attached to the light cavalry, for example Augereau formed a horse battery of two 8-pounders and one 6″ howitzer. The organization of the corps engineers will be treated at length later on, and the organization of the administrative services was so complicated that it cannot be dealt with here.

The composition of the Grande Armée itself varied at various periods of the 1806-7 campaign and is well known to the students of its different phases. It is only necessary to point out that Napoleon disposed of a reserve of artillery which was attached provisionally to the Guard Corps to Oudinot's Division and to the mobile artillery park. At Jena it amounted to about 30 guns.

We will now consider in detail the organization of the engineers. The Chief Engineer of the Grande Armée was General Chasseloup, who was assisted by General Kirgener, as Chief of the Staff, and by 7 to 10 engineer captains. Up to September, 1806, the engineer troops and tools were attached to the mobile artillery park, but before leaving for Saxony, Napoleon ordered the formation of a special engineer park composed of a detachment of miners, 1,000 sappers and 10 engineer officers, with carts carrying from 3,000 to 4,000 tools, which was to be organized in two parts. This park was actually formed on the 5th October, and was divided into two brigades

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each about 800 strong. The 1st Brigade under General Cazals had a staff of 3 field officers and 5 captains, and consisted of 2 companies of miners, and 1 battalion and 2 companies of sappers. The 2nd Brigade under Colonel Dabadie possessed a staff of 1 field officer and 6 captains and was composed of 2 mining and 4 sapper companies; 4 more companies of the 4th Sapper Battalion were to be added to complete it.

By the 7th November the number of tools with the park had greatly increased and amounted to 15,000, consisting chiefly of entrenching tools, with a proportion of carpenters', joiners' and wheelwrights' tools. 24,000 tools were captured at Spandau, and 12,000 more were being sent up from Strassburg to Berlin, whilst 10,000 were retained at Würzburg, Kronach and Wittemberg as there was no transport available for them.

The bridging train formed no part of the engineer park, but moved with the mobile artillery park. It was commanded by Major Dessales, with a staff of 2 captains, and consisted of 7 pontoon companies with 18 officers, 569 men and 587 horses. On the 3rd November its material included 18 boats and 14 Prussian pontoons. In spite of the capture of the Prussian pontoons at Naumburg, the material of the bridging train was quite insufficient, so that when in December the army reached the Vistula, a river about 1,000 feet in width at this part of its course, it was detained nearly three weeks, as it was found impossible to throw bridges across the river suitable for the passage of the cavalry and artillery.

In each army corps, the engineers were commanded by a colonel, assisted by 1 major and from 2 to 4 captains. The colonel had directly under his orders the engineer park, which consisted of 1 or sometimes of 2 companies of sappers and a detachment of miners, with 5 or 6 tool wagons and 1 mining wagon per company.

The engineer officers, in addition to performing the ordinary technical duties of their corps, such as the construction of fieldworks, the repair and destruction of communications, and bridging, were engaged in many duties which would at present be left to officers or the General Staff. They were employed especially on reconnaissance work, in making sketches and road reports, in working out tactical problems, and in keeping the journal of the operations of the corps to which they were attached, with plans of the positions occupied, details of the actions, dispositions for attack and defence and a general criticism on all that had happened.

The engineer officers also assisted the topographical engineers, a description of whose work will be found later on, in making the maps, plans and sketches required by the Emperor and his marshals.

At the commencement of the Jena Campaign Napoleon devoted much attention to his engineers and ordered Berthier to see that plenty of entrenching tools were provided. On the 5th October,

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1806, he wrote from Würzburg to Soult telling him to be careful that "3,000 to 5,000 entrenching tools always marched on a level with his divisions, so that a redoubt or simple trench could be made if circumstances required it."

The mining companies had each been provided with one tool wagon long previous to the opening of the campaign, but the sapper companies had not been so well supplied and were very badly equipped, getting merely whatever material was available in the army corps park. On the 1st October, 1806, however, Napoleon issued a decree from Mainz by which each sapper company was to be provided with one 4-horse wagon containing 500 tools. One similar tool wagon was allotted to each infantry division, and two or three to each army corps, which accordingly carried 1,000 to 1,500 tools. The special wagons which were ordered to be built for this purpose did not reach the army until the middle of 1807, and in the meanwhile the tools were carried in specially requisitioned vehicles.

In spite of these arrangements the army was as a whole very deficient in engineer troops and equipment. Augereau's Corps was the best supplied in this respect, as from the very commencement of the campaign it carried 1,000 entrenching tools packed in 12 wagons. It had also two sapper companies, one of which remained with the park, whilst the other was divided amongst the two divisions of the corps. In the remainder of the army there was only one or at most two engineer captains and no engineer troops with a division. These officers were attached to the divisional staff and were charged with all kinds of reconnaissance duties. They reported on the defence of villages and woods, and on how to block or defend defiles. They superintended the execution of all kinds of works and they were sometimes detailed to choose camping grounds, to prepare route reports, to reconnoitre bridges, obstacles, etc., and in fact, as is said in *Le Spectateur Militaire*, Vol. XIV., p. 393, to carry out all those staff duties which were classed as *fonctions savantes* as opposed to *fonctions militaires*.

Whenever a division had to execute fieldworks, the Marshal sent up engineers and tools from the corps park, and the engineer captain on the staff of the division took charge of the work, the regimental sappers, infantry working parties, and civil labourers being put at his disposal.

Davout's Corps was the only one which possessed its own bridging train. On the 29th September, 1806, orders were issued to the Commanding Engineer of this corps to organize a light bridge train consisting of two boats per division and two for the Headquarter Staff. The boats with their equipment were transported on requisitioned vehicles with the engineer park.

During the 18th and early part of the 19th century accurate maps were very rare and in many cases entirely wanting, the duties of the

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topographical section of the General Staff were consequently very heavy. Under the Bourbons there had been a *corps des ingénieurs-géographes des camps et armées*, but it was abolished by a vote of the Constituent Assembly in 1791 on the motion of an engineer officer, Bureaux de Pusy. It was intended that the requisite topographical work in the field should be carried out by engineer officers in addition to their other duties, but it was soon found that this plan would not work satisfactorily and in 1793 the *Dépôt de la guerre* was re-formed and charged with the preparation of maps and plans. In the year XI. the corps of geographical engineers was again founded, with an establishment of 108 officers, under the command of General Sanson. During the Austerlitz Campaign it was known as the *Bureau historique et topographique*, but from 1806 onwards it was called simply the topographical service of the Grande Armée.

The work of this section was extremely hard. Its officers were employed in front of the army, and were frequently wounded or taken prisoner. Immediately after the Battle of Jena there were at General Headquarters 1 major-general (Sanson), 2 field officers and 9 first and second class engineers; and with each army corps there were 4 or 5 engineers.

The duties of the topographical service were three in number, viz.:—

(1). To mark every day on the general map the position of the army.

(2). Immediately after an action to make plans of positions that had been occupied and of the field of battle.

(3). To reconnoitre the country and the routes to be followed by the army, and this reconnaissance included the obtaining of statistical information regarding the resources of the country.

Napoleon demanded an immense amount of work from the topographical section, and at the commencement of the 1806 campaign its establishment seems to have been insufficient for the duties imposed upon it. Thus on the 2nd November the Emperor ordered Sanson to detail four officers to reconnoitre the Oder from Frankfort to the Baltic, together with the country lying for 3 leagues on either bank, on the supposition of a defence of that river supported by Stettin and Küstrin. Five days later he ordered four more officers to be sent to Posen to reconnoitre the environs of that town on the supposition that a battle would be fought there against the Russians, who were thought to be on the point of crossing the Vistula. The result of these orders was that Sanson was left with only one engineer-geographer under his orders at General Headquarters.

On the 2nd December, 1806, Berthier issued orders that in future all the engineer-geographers were to be directly under the command of

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the *troisième aide-major général* (Sanson), who was to detach one of them with the advanced guard of each army corps for the purpose of making route reports, which were to be forwarded daily to Sanson for the Emperor's information. On the 1st May, 1807, the strength of the *personnel* of this section amounted to 1 major-general with his aide-de-camp, 2 heads of section, 13 first class engineers, 7 second class engineers and 10 third class engineers, or 34 officers in all, a strength which appears to have been sufficient to deal with the duties entrusted to it.

Napoleon attributed at all times the greatest importance to the topographical service. Wherever he was, it was his custom to allot one of his private apartments as a map room. This room contained a very large table on which to spread out maps and plans. At the Tuileries the map room lay immediately between the Emperor's bedroom and his study.

In 1806, Bacler d'Albe, who had been through the 1796 campaign in Italy as engineer-geographer to General Bonaparte, was appointed head of the Emperor's topographical bureau. His duties were to be present whenever the Emperor wished to read despatches with the map; he marked on the map with red and white pins the positions occupied by the troops, both friends and enemies; he coloured the maps so as to bring out the chief strategical features, and made any calculations of distance that were necessary.

As soon as the contents of despatches had been applied to the map in this manner, D'Albe made a short report to the Emperor, and Baron Fain (premier secrétaire du cabinet de l'Empereur) relates that the Emperor used to follow all the dispositions with his finger and measure the distances between the pins with a pair of compasses.

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GIBRALTAR UNDER MOOR, SPANIARD, AND BRITON.

(Concluded).

By Col. E. R. Kenyon, R.E.

The Towers round the Coast.

During the 16th century Gibraltar in common with the rest of the coasts of the Mediterranean was harassed by the pirates whose chief, Barbarossa, was a terror to all the Christian coast lands. On 8th September, 1540, a force of some 2,000 of these Turkish pirates arrived off Gibraltar and disembarked before dawn the next day in the bays of Almadrabilla (north-east of Europa Point) and Laudero (now "Little Bay"). At dawn they moved forward in three parties, one against the Castle, a second towards the town, and a third in reserve and ready to collect and embark the spoil. They penetrated into the "Turba" ward before the alarm was raised; the Christians fled to the walled ward of the Barcina and the Castle; the pirates plundered the Franciscan Convent (now Government House), and then after some street fighting withdrew to re-embark with their plunder and captives, being joined on their way by the third party which had meanwhile sacked the hermitage of Europa. The whole re-embarked after being four hours on shore, with 70 prisoners, of whom only six were men. They then anchored at Puente Mayorga (Orange Grove) where they plundered vessels and houses, but not without loss as they encountered Spanish reinforcements which had come in from Jimena. Negotiations for ransoming the captives were ultimately brought to a satisfactory conclusion. It is satisfactory to note that the pirate squadron shortly afterwards fell in with that of the Spaniards under Don Bernardino de Mendoza and was completely destroyed with the loss of its two leaders, 800 Christian captives being liberated from the galleys, and 400 Turks being captured.* The raids on the Spanish coasts however continued, and as the fleet was insufficient to give adequate protection a series of 44 towers was built along the coast from the mouth of the Guadiaro to the Portuguese frontier at the end of Philip III.'s reign (about 1618).† Several of these towers still remain, such as those on the eastern shore known as the First and Second Towers, and the Rocadillo tower near the mouth of the Guadaranque. There was however an

* Montero, pp. 227—239.
† Ayala, p. 265.

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earlier set of towers, some (if not all) of which were known as "Genoese." One of these stood above Laudero Bay and was occupied on the night of the pirate raid by two sentries who challenged the Turks, but ultimately had their suspicions lulled to rest by the answers they received, as narrated by Montero and Ayala. Another "Genoese" tower is mentioned in the Spanish Orders for the siege of 1727; and the same tower is no doubt referred to in the Remonstrance quoted in a former *Journal*, but the reason for describing these towers as Genoese is not known. Ayala (p. 33) in speaking of the one above Laudero Bay says "There was in this place a very ancient tower called that of the Genoese, without it being known why this name was given.* It may be conjectured that it was erected to correspond with another, which was outside the city, of almost identical construction on the summit of the Sierra Carbonera and that the Carthaginians or Romans had them made to warn Carteia of fleets approaching from the sea." The tower on the Carbonera, that of Cartagena and that at Martin Flores (Miraflores)† are mentioned in a document of November 18th, 1469, giving a list of the guards to be maintained and of their pay, which is printed as Appendix V. of Ayala. Montero in describing the ruins of Carteia says that the Rocadillo Tower, which is one of those mentioned above as built in the reign of Philip III., was probably erected upon the foundations of an older one, it being generally believed that the Carthaginians had introduced that method of watching the coasts. The history of the Devil's Tower is not known but its masonry is similar to that of the Sierra Carbonera Tower and it may, like the latter, have been one of the older series of "Genoese" towers.

It may be suggested that these Genoese towers may have been erected by Genoese workmen (perhaps early in the 16th century when Italian engineers were busily employed on fortifications under Charles V.) and that these workmen settled in the little cove now called "Catalan Bay," and that from them the name of "Genoese" came to be applied by the Spaniards both to the towers which they built and to the cove where they dwelt.

To the tower on the Sierra Carbonera the name of "Queen of Spain's Chair" has been attached, and to explain it an absurd legend has been so often told that it has been frequently believed to be true, to the effect that the Queen of Spain took up her position there during the great siege and said she would not move thence until she

* A "Genoese Tower" is marked on one of the plans of 1627 above Laudero Bay but well inland, being shown as nearly due north of the Chapel of "Our Lady of Europa" (British Museum Add. MS. 15152). It seems highly probable that the ruins described by James and known as "The Inquisition" were the remains of this tower. These ruins no longer exist.

† Montero, p. 203.

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saw the British flag lowered and that the Governor, in courtesy to her, allowed it to be hauled down for a few minutes; but that this is utterly without foundation is shown by the fact that we find the name used by Spilsbury and Drinkwater at the very beginning of the siege. On the other hand it is never used by James who left Gibraltar in 1755; and in one of his plans he gives a view which includes the Sierra Carbonera and marks the peak as "Mountains in Spain" whereas if the name of "Queen of Spain's Chair" had been then in use he would almost certainly have employed it. Thus it would seem that this name must have come into vogue between 1755 and 1779. An explanation of the name is given* in a Spanish book *Gibraltar y sus Alrededores* published in 1857 that some Spanish visitors were so charmed with the view from this spot that they said it would delight even the Queen herself to see it. The name is, however, not in use among Spaniards.

The name of Windmill Hill Flats is derived from the old mills which formerly stood a little to the east of the military prison (now Detention Barracks), but of which no trace remains. During the siege of 1779–83 General Eliott caused a new mill to be built on these flats, but on the night of March 21st–2nd, 1782, it was burnt down (Drinkwater and Spilsbury). Probably the ruined tower near the southern end of the flats is the remnant of this mill. The two ancient mills are shown on the 1745 plan in the Royal Engineer Office but only as two towers "formerly erected for windmills." In the time of Colonel James (1755) these flats were known as "Upper Europa."†

Some Names not previously Noticed.

Irishtown is the sole relic of an ancient custom which seems to have prevailed of naming districts after some prominent person or characteristic. For instance the following are to be met with in Garrison Orders and old journals:—Blacktown (G.O. of 30th June, 1787); Haynes's Town (G.O. of September 3rd, 1787); Hardytown (Drinkwater, 23rd May, 1781).

City Mill Lane is probably a corruption of Siete Vueltas (Seven Turnings, in allusion to its very winding nature). The name of City Mill Lane occurs in Garrison Orders of 20th January, 1780; but in those of 17th October, 1777, it appears as "Citamell Lane." The letters *v* and *m* being both labials may be interchanged without much difficulty. Another explanation which has been offered is that the name is a corruption of City Mall Lane, "Mall" being the old English word applied (as in Pall Mall) to places where certain games were played; but this idea hardly commends itself to those acquainted with the narrow sinuous lane and its neighbourhood.

* *Gibraltar Chronicle*, April 30th, 1909.
† Plan in James' *History*, Vol. II., p. 321.

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The "*Black Hole*" or punishment cell for soldiers used to be at or near the site now occupied by the "Haven," the residence of the Colonial Treasurer who, it is to be hoped, finds it a more comfortable haven of rest than the former occupants of the site, who were under the care of the Main Guard which was where the Military Police Guard now is in Commercial Square, the old Grand Parade.* The "Black Hole" was the ordinary military name of such cells. For instance the notorious "Black Hole" of Calcutta, into which Surajah Dowlah crushed his unfortunate British prisoners, was the ordinary military punishment cell for a single soldier.

Arengo's Palace never was a "Palace," but was the residence of a Spanish family of that name, a member of which is nominated as Spanish Vice-Consul in a letter of 18th May, 1805, in a letter book at Government House (p. 169).

Buffadero Battery is perhaps an anglicized corruption derived from the Spanish "bufido" which means "blowing" or "snorting," a name which might have arisen from its wind-swept position; or it might be of Genoese origin, many Genoese workmen having been employed in Gibraltar. It is interesting to note that Buffavento is the name of a castle in Cyprus which was a favourite residence of the Lusignan queens.

Catalan Bay.—Whatever the origin of this name may have been, it certainly serves to keep alive the memory of the assistance rendered in the defence of Gibraltar by the Catalans after its capture in 1704. Montero, in his general description of the fortress as it was in 1704 (p. 276), says that this bay "was, and still is, called the Bay of the Catalans." This, however would appear to be a mistake, for the name does not seem to occur in any documents or plans earlier than 1745. When reference is made to that neighbourhood, as in the diaries of the siege of 1727, it is spoken of as the "back of the Rock" or "behind the Rock" and not under any specific name. It first appears on the plan dated 1745 in the R.E. Office, but as it, like all the other names on that plan, is written in ink it is possible, although not probable, that it might have been added at a later date. It appears also as "Catalan's Bay" in the print of a Perspective East View of the Rock which hangs in the Garrison Library and which was published in 1750. It therefore appears that the name came into use between 1727 and 1750 and probably before 1745. An explanation frequently given is that it was an English corruption of the word caleta ("a small bay") but as this name applied equally to all the other small bays round the Rock the explanation does not seem very probable, although some colour is given to it by a print in the Royal Engineer Mess, dated 1800, showing a view of "Catalan or Caletta Bay." A correspondent of the *Gibraltar*

* James, Vol. II., p. 350

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*Chronicle** says that the *Diccionario Universal* published by Don Nicolas Serrano says that the bay is so called "because the inhabitants, a Genoese colony, follow the same trade of fishing as the Catalans"; and that no Catalans at any time lived there. It does indeed seem to be most probable that the name is really due to a confusion in the minds of the British garrison between the Genoese and Catalans. Both took an active share in defending the place. For instance in Garrison Orders of July 31st, 1720, the "Catalan Guard" is mentioned; on October 20th, 1726, "Catalainia" is mentioned in a list of the Guards; on July 4th, 1728, and on January 10th, 1729, "the Genoese Guard" is mentioned; and references to the Genoese are frequent in Orders and Journals. Of 22 surnames now in use at Catalan Bay 15 are of Genoese origin, 3 are Spanish, 3 are Austrian or Polish, and 1 is doubtful. Both Catalans and Genoese used to wear a peculiar red cap; both were foreign to the British garrison; both followed the pursuit of fishing; and both furnished guards to assist the English. The confusion between the two might therefore very easily arise; and this would be encouraged by the fact that the military authorities seem to have considered the Genoese and Spaniards resident in Gibraltar as people to be dealt with together. Thus in Garrison Orders of 24th July, 1720, it is directed that all "Spaniards and Genoese" able to bear arms are to be reviewed.

Some confirmation is given to this theory by the Spanish Orders for the siege of 1727† in which it is directed that "This day (February 22nd) is to be put into execution the opening of our works and batteries against the garrison from the Devil's Tower (now named S. Pedro) through the middle of the sands to the west strand; the parade of arms is to be established on the east strand near the Genoese Cove . . . the Lieutenant-General to be with the workmen . . . and to take up the ground from the first parade of arms to the tower of St. Peter . . . the Major-General is to take up the second parade of arms from the east strand to the Genoese Tower and to detach 2 officers with 30 men each to take up the ground from the Genoese Cove to defend the corner of the Rock in case of a sally from the garrison; . . . the Brigadier-General to run his trench from the Genoese Cove till he joins the situation of the first battery."

The Spanish Lines taken up in accordance with this order ran from the north-east corner of the Rock diagonally across the sands to the western beach. The "Genoese Cove" must refer to Catalan Bay, for there is no other cove in the neighbourhood. The cove being then known to the Spaniards by the name of its foreign inhabitants

* Father Jones, April 30th, 1909.
† James, Vol. II., p. 240.

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it is easy to see how the British soldier would readily adopt the same nomenclature and, confounding Genoese with Catalans, and also hearing the place spoken of as a "caleta," would give it the name of "Catalan Bay."

The "*Europa Hotel*" or "*Hotel de l'Europe*" stood on the site now occupied by the southern end of the Admiralty workmen's buildings, or New Mole House. It was the scene of a grand farewell entertainment given to Prince Edward (afterwards Duke of Kent) on 11th May, 1791, prior to his departure for Quebec. The "ruins of an adjacent barrack" were fitted up for a ball and supper arranged by Capt. Fyers, R.E., as part of that entertainment.*

Mount Misery is a name now attached to a part of the crest of the Rock, but according to a MS. which appears to be of about the year 1767† the name originally applied to a work on the New Mole. Section III. of this MS. in describing the "new or south mole" says "It runs into the sea only about 110 yards in length. . . . The Mole batty or high Platform faced formerly towards the N.W. but there has been a new one made lately facing about S., mounting 10 guns by which it is greatly strengthened. In it is the Remains of a very high square wall once called Mount Misery because the Breaking down thereof was ordered as a Punishmt."

GIBRALTAR IN ITS TERRITORY.

Algeciras, Los Barrios, San Roque.

The town of Algeciras which faces Gibraltar from the western shore of the bay has seen many vicissitudes and has played a prominent part at various times in Spanish history. It was founded with materials obtained from the ruined Carteia‡ by the Moors almost immediately after their invasion of Spain under the name of Alghezyrah-Al-hadra or "The Green Island"§ which name in its Spanish translation is now applied to the small island (La Isla Verde) off Algeciras. "From 756 to 1031 Gibraltar lacked importance, being only a subordinate fortress of the Government of Algeciras which was then the strong and populous city, ruled by Royal princes, and the most important on the Spanish coast facing the Straits."‖

* *Life of the Duke of Kent*, pp. 27 and 28.

† Now in the possession of Major Harrison, Secretary, R.E. Institute.

‡ Montero, p. 52.

§ There is some doubt whether this name belonged in the first instance to the town, or whether it was not gradually confined to it after having been originally applied to the whole of Andalusia to which is given the name Al Gehzyrah (The Island) by Al Makkari who explains that lands washed by the sea on three sides were commonly called "islands."

‖ Montero, p. 94.

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The remains of the Moorish aqueduct which supplied it with water are still to be seen in the neighbourhood, as well as some traces of the ancient wall of the town. "It is a singular fact that the only detailed notice of a Moorish hospital in the Peninsula is of that of Algeciras, which was founded in the 12th century. Tradition reports, however, that 50 public institutions of this kind existed at one time at Cordova."* In the year 1344 Algeciras was captured by King Alfonzo XI. after a siege of 20 months, in which he was assisted by Crusaders of many nations including a considerable English force, among whom were Edward III.'s grandson, the Earl of Derby, the Earl of Salisbury, and others. It is said that cannon were first used in Europe during this siege, the Moors making use of them in their defence. Two years later they were used by the English at Crecy. In 1370 Mahomed V. of Granada recaptured Algeciras during his war with Henry, the brother of Pedro the Cruel, after the latter had been murdered by the former with his own hand. Mahomed utterly destroyed the place†; and in December, 1462, King Henry IV. granted all its territory to Gibraltar,‡ which had been recovered from the Moors in August of that year. After the capture of Gibraltar in 1704 by the British, its Spanish inhabitants migrated and refounded the city of Algeciras, as well as founding those of San Roque and Los Barrios. The three combined were referred to in Royal despatches as "My city of Gibraltar resident in its territory" (campo), but San Roque was its head§ until 1756 when they were divided,‖ although the Governor of the whole continued to reside at San Roque until General Castaños moved to Algeciras, a change which received the approval of the Government in 1808.¶

Campamento, Jimena, and Castellar.

Other places in the neighbourhood also owe their rise to, or are connected with Gibraltar. Campamento, which lies on the outskirts of the ancient Carteia, was originated by the buildings constructed for Spanish troops in 1779.** Jimena was taken from the Moors in 1431, recaptured by them in 1454, and finally by the Spaniards in 1456.†† During the siege of 1779–83 factories for shell and cannon were established there.‡‡ In 1810 its castle was put into a state of defence by the guerilla General Ballesteros who was attacked there by a

* Scott, Vol. III., p. 516.
† Conde.
‡ Montero, p. 196.
§ *Ibid*, pp. 280—326.
‖ *Ibid*, p. 331.
¶ *Ibid*, p. 382.
** *Ibid*, p. 339.
†† *Ibid*, p. 392.
‡‡ *Ibid*, p. 340.

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detachment sent against him by Soult.* Ballesteros deceived the enemy by a pretended flight and then fell on him and routed him with a loss of 600 among the crags between the River Hosgarganta and San Roque. Soult furious at this defeat, sent Oudinot with 10,000 men against him, but Ballesteros eluded him and took refuge under the guns of Gibraltar.

Castellar, like Jimena and Ronda, was one of the fortified posts on the frontier of the Moorish Kingdom of Granada and was consequently, like them, frequently the scene of battle. It was taken from the Moors in 1434 by the Alcaide of Jimena, and like that place was again taken and retaken. An interesting anecdote illustrative of the manners of the times, as well as of the nature of much of the fighting, is told of a combat in the woods of Almoraima. Washington Irvine tells it in his *Conquest of Granada;* and the following is a translation of Montero's narrative (pp. 210, etc.). Muley Hassan, King of Granada, "with an army of 1,500 horses and 6,000 foot passed by Marbella and Estepona and following the sea shore entered the territory of Gibraltar. Leaving this place on his left hand . . . and detaching 400 men to observe it . . . he sent 200 to raid the lands of Tarifa and a similar force into those of Medina Sidonia . . . Pedro de Vargas (Governor of Gibraltar) marched by night with 70 horse to Castellar, by which place Muley would have to pass on his return. On arriving there he had beacons lighted to alarm the country and sent messengers to Jimena and Alcalá calling for help. Muley realizing from the beacons that the alarm had been given hastily marched for his own frontier carrying his booty with him. He sent an advance guard of 300 horse . . . who were surprised in the Almoraima Woods by Pedro de Vargas . . . who retreated to Castellar with a part of the recovered herds. Muley followed with his main body, and pursued the Christians to the gates of Castellar and set fire to the houses outside the walls. There he halted, collected the herds which had scattered among the hills, and ordered that they should defile in full view of Vargas and his troops. To close the adventure he sent one of his officers with twelve of the best cattle as a present to Vargas, saying that he did not wish to deprive of his rights so valiant an Alcaide whose activity in collecting his dues had been apparent on this occasion. This proceeding pleased the Alcaide who replied in the same humorous style thanking him for the payment which he had made and expressing his sorrow that his scanty forces had not permitted him to receive him with greater pomp at his entrance into the district, but that he was expecting 300 horsemen that night from Xerez and that if they arrived he would attend on him at dawn with them. With this message he sent a rich cloak as a gift. Muley heedful of the warning and fearing the riders

* Montero, p. 384.

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of Xerez pushed on his march through those rough mountains so precipitately that he abandoned more than 5,000 head of cattle which were recovered by the Christians, returning to Malaga with the rest of his spoil well satisfied with his expedition." * The name *Almoraima* is a Moorish word meaning "payment of fines,"† and perhaps owes its origin to the fines of cattle which were exacted by the Governor of Castellar from all herds passing through his territory, to which Muley Hassan referred in his message to Pedro de Vargas.

Carteia (*see Montero, pp.* 52, *etc.*).

Carteia was a Phœnician colony and is stated by Strabo (Book III.) to have been founded by Hercules.‡ Montero derives its name from Melkarth, the god of Tyre, and places its foundation at about 1,000 B.C. It was stormed by Hannibal in 220 B.C. but revived again as the Roman city of Tartessus, a name which was applied not only to it but to the whole of the south-western corner of Spain from Gibraltar to Cadiz. By many it is believed that this name is identical with the Tarshis of Scripture§ to which the fleets of Solomon cruised. Hither fled Cnœus Pompey after his defeat by Julius Cæsar at Munda (B.C. 45) which was in the vicinity of Ronda, and from its water gate he escaped, though captured shortly afterwards and executed. Coins prove that the city still existed in the time of the Emperor Honorius (395—423 A.D.) in whose reign Rome was sacked by Alaric, King of the Visigoths; but it is probable that it was destroyed about this time by the Vandals who overran Spain A.D. 410—425 and who left their name to Andalusia. Nothing now remains of the city except some massive fragments on one of its hills of what appears to have been a great square keep or citadel and the ruins of its docks which may still be clearly traced at low water, but it must have extended from Punta Mala to the River Guadarranque. Its ruins furnished materials from which Algeciras and Gibraltar were built and also San Roque when the inhabitants of Gibraltar settled there after their exodus in 1704. In 1845 the remains of buildings were discovered and statues, coins, and other articles were dug up between Puente Mayorga (Orange Grove) and Campamento. Among these were many large jars (amphoræ) with pointed bases, two of which are in the Gibraltar Garrison Library. They appear to have been funereal urns, as they contained ashes and calcined bones. It is

* Montero, pp. 210—212, on the authority of Alonso de Pal, Book 28, Chapter 3).

† Montero, p. 203.

‡ It is nearly certain that all references and traditions relating to a town at Gibraltar prior to the Moorish capture in 711 really relate to Carteia.

§ Smith's *Classical Dictionary*.

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said that the city was supplied with water by an aqueduct of which remains may still be traced in the neighbourhood of San Roque,* consisting of a long underground channel on the western edge of the almond grove and some masonry fragments in a small vineyard a little further to the north. This channel is in very good preservation. It is built of stone and is about 5′ in depth when cleared of the earth which has accumulated in the interior. If however this aqueduct conveyed water to Carteia it can only have done so to the lower parts of the town or to gardens and fields in the surrounding valleys since it lies about 150′ below the level of the ruins of the citadel. This citadel, or keep (now known as "El Castellon"), is a square of 40 yards side with a wall 2′ thick and the ruins of three turrets at three of its angles. The north-west corner has no turret. The two facing eastwards were small in size, but that at the south-west was a massive structure measuring 24′ × 18′ internally with a brick vault below which may have been a tank or store. This turret commanded a magnificent view of the surrounding country especially towards the river and bay, and no doubt it was the principal watch tower of the place. It was the first Spanish fortress seized by the Moors after their disembarkation in the bay, and was known by the name of the Tower of Cartagena.

Hunting with the Calpe Hounds.

No account of Gibraltar can be complete without some reference to the "Royal Calpe Hunt" but it may be more interesting to "see ourselves as ithers see us" than to look at the excellent sport enjoyed with this pack through English glasses.

The following account is therefore extracted from the translation of an article which appeared in a Vienna paper *The Sport*. The author was an Austrian cavalry officer who joined the Mexican Foreign Legion and who spent a few days at Gibraltar with his regiment of Lancers on their way out in December, 1864, on board the *Peruvian*. The translation appeared in the *Chronicle* of February 14th, 1865. The meet was at San Roque. "The party consisted of 93 gentlemen and 5 ladies. No one of us would have thought it possible to hunt over a ground of this nature. It is a sign of the strongest passion for the noble sport to hunt in a country which is even on foot very difficult to pass over. It is almost impossible to describe the difficulties to anyone who has not seen them himself. These hills are only to be compared to the Austrian Karst Mountains, whilst at Gibraltar there are still more loose stones, the heights are even more precipitous, the water courses and ravines

* Montero, p. 70.

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even rougher and deeper. Besides, the stony ground is almost entirely covered with brushwood 2′ or 3′ in height which hides holes and pieces of rock. Over these hidden obstacles even the most sure-footed horse is liable to fall. Who would believe that there, where one might expect only chamois to climb, one should meet a whole hunting field, not only consisting of gentlemen but even of ladies galloping with the greatest temerity down the hills? It was really frightful for us, unaccustomed to such daring feats, to see the most fair and lovely apparitions in the shape of English ladies in such evident peril. Our hearts were beating anxiously seeing them suspended over precipices where a moment of hesitation or the false step of a horse would have been sufficient to dash rider and horse to pieces. But the keen eye and the steady behaviour which distinguished them throughout assured us that they easily and surely surmount those dangers. All appeared perfectly at home on their horses and rode them with perfect ease and grace. . . . First we found a fox in the Pine Wood and ran him to ground. After this we came to some ground torn by furrows and chasms and without any wood. This ground and its difficulties for hunting defy description, and in vain do I look for words to express my astonishment at the courage and intrepidity of the English gentlemen and ladies. Only those who have learnt to ride in the 'Central Cavalerie Schule' over the Austrian Hochgebirge, will have an idea of the demands which riders and horses have to answer. We soon found another fox and then followed several very exciting runs. We rode without stopping over rocks almost as steep as a roof and through streams of water. Unfortunately they did not kill as they had so well deserved." The present Master is Don Pablo Larios to whom the garrison of the Rock owes everlasting gratitude for the sport which he and his family have done so much to maintain.

Rainfall.

Life at Gibraltar is so greatly affected by the rain that this article may fitly be closed with a few of the more important facts about the rainfall which has been regularly recorded from the year 1790. Its average amount per annum up to 1908 inclusive has been 33·12″ but its variation is very great. During this period it has varied from 15·12″ in 1800–01 to 77·14″ in 1855–6. Seven times the fall has been less than 18″ and 12 times it has exceeded 50″. The highest recorded fall in any one day during this period was on 14th December, 1796, when 9·13″ fell; but in the *Encyclopædia Britannica* (Vol. XVI., p. 150) it is stated that on one occasion (the date of which is not given) 33″ fell in 26 hours. Possibly this was on 30th January, 1766, on which day Ayala (p. 365) records a tremendous fall of rain which blocked the streets with *débris* and drowned 50 people. Colonel

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Skinner states that it destroyed 130′ of the Line Wall at Rosia.* Falls of from 4 to 6″ in one day are recorded fairly often, and it may therefore be easily understood that the rivers and streams in the neighbourhood vary greatly in depth and that the fords are constantly changing. An accident which occurred on 13th December, 1864, illustrates this danger. Ordinarily there is no difficulty in fording the mouth of the river at Puente Mayorga (Orange Grove) but after heavy rains it is sometimes impassable. On that day an Irish car with four officers in it, a driver and a postilion was carried away by the current at that spot and upset. All were drowned except one officer.†

* An extract from a report by Major-General Irwin dated February 3rd, 1766, is published in the *Annual Register* for 1766 (p. 74), from which it is seen that it was a violent thunderstorm with heavy showers of hail. "Between 8 and 9 at night the whole hill and town seemed to be on fire, and spouts of water poured down from the clouds. . . . In a few minutes the ground floors of all the houses in the town were full of water, the hail and rubbish having stopped up the drains. . . . Almost everybody in the town has suffered. It is scarcely possible to describe the melancholy scene of parts of houses, furniture, men, women, children, and animals of all sorts floating in the water, or stuck in the rubbish: and do suppose that since the misfortune at Lisbon, so dreadful an accident hath not happened to any town; nor could anything more resemble that than this, many of the streets being entirely choked up with the rubbish, and the inhabitants obliged to come out at their upper windows, and some to break their way through the tops of their houses."

† *Gibraltar Chronicle.*

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MODERN FIRE APPLIANCES.

A SURVEY OF PROGRESS.

By CAPT. E. H. HARVEY, LATE R.E.

THE rapid development of and improvements in modern apparatus and organizations for saving life and property from fire, have been already alluded to in previous papers which I have contributed to the *R.E. Journal*, and, now that to a great extent these innovations in the shape of motor and other special appliances have undergone the test of service, it may not be without interest to engineers to add a few further notes on the subject. R.E. officers have at times to consider questions of the public service of towns and districts outside their immediate barrack and military duties, and it is hoped therefore that the information here given may be of some use, as a record of what has been done in municipal and public work for efficient fire protection up to the present date.

Improvements in Life-Saving Apparatus.—It is noteworthy that, up till about 13 years ago, no very great departure had been made in English fire-brigade practice from the standard machines and methods in use since the introduction of the steam fire engine in the "sixties," and of the telescopic fire escape. Improvements in detail—in quick-steaming boilers—and in reducing the weight of apparatus, etc., had, of course, been in progress; but no very marked improvement in the means for life saving was generally brought forward until about 1897, when the introduction of the horse-drawn fire escape in London showed the first important advance in modern methods.

The old system of hand-drawn escapes stationed in the streets, and each manned by a couple of firemen detached like "outposts" from the district fire station, had the disadvantages of dispersing the strength of the available *personnel*, and of exhausting the men with the labour of hauling their machine to the scene of action, before they could even commence their work of rescue, and the now well-known horsed escape, bringing a fully manned crew fresh from their quarters and ready for vigorous action, has proved to be one of the greatest benefits to the public service that has yet been introduced, though light hand escapes stationed at suitable points are sometimes a valuable auxiliary in many towns being worked by the police as well as by firemen.

Adoption of the Chemical Engine.—Not long after this improved appliance had been brought into extended use in London and the

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provinces, an addition of great utility suggested itself in the form of the "Chemical Engine" which had long previously been in vogue in America. The cylinder containing—in the various sizes—a supply of from 35 to 60 gallons of water, was found capable of convenient attachment transversely (usually under the driver's seat) to the carriage of the escape, and at the time of the Fire Exhibition of 1903 at Earl's Court, a combined machine of this pattern was exhibited, having a small-bore hose coiled up ready for immediate use with the chemical cylinder in a cage, which permitted of its being run out with the utmost rapidity immediately on arrival at the scene of work. This was in addition, of course, to the supply of full-sized hose, standpipes, branchpipes, etc., for work with the street hydrants or ordinary fire engines.

"First Turn-Out" Machines.—This form of appliance—combining in itself "first-aid" engine and escape with hose—has since been adapted to motor propulsion with success, and in most up-to-date fire brigades is the machine that is generally found to be most suitable for the "first turn out" on receipt of a call. The experience of the London authorities alone, since its adoption, has amply proved its value in the saving of many lives and much property. The chemical engine, it may be remarked, is really a modern and scientific application of the principle, long adopted on the Continent, of turning out on the first call a small manual engine with hose-reel and a water-cart—enabling a small jet of water to be brought into action almost immediately on arrival at a fire, while, it may be, a long line of the larger hose is being laid down to the nearest available hydrant, or, in some cases, while a steam fire engine is delayed for a few moments in getting up its full working pressure.

The horsed or motor escape will usually be followed at once by a steamer, except in attending small fires in towns that have a constant high-water pressure on the mains, and a very complete hydrant system, when experience may show that the latter alone is sufficient to deal with ordinary outbreaks, the steamer being held in readiness and sent on on "second call." This system of working from hydrants alone, while economical, has its risks unless all calls are received in some detail by telephone (if not verbally), and great discretion and forethought are used in ordering the steamers out at once, on the first information received.

Special Uses of Chemical Engines.—The chemical engine has its special value in districts where hydrants are few and far apart, and on high levels in hilly places where the water pressure on the hydrants may not always be satisfactory during the first few moments after a fire has broken out: *i.e.* until the waterworks have time to increase it and make necessary arrangements. In selecting appliances for use on hilly roads it must, however, be remembered, that the weight of some 40 to 50 gallons of water in a strong metal tank with

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special hose and other attachments, is a considerable addition to the total weight to be hauled, though in this particular a motor-driven machine would be little affected in comparison with one drawn by horses. Obviously, too, the machine should be stationed at a high level in the district where it is wanted, although many fire brigades have yet to put up with stations at low levels, and inconveniently placed.

A later modification of the "chemical engine" adopted by the London Fire Brigade several years ago, and since elsewhere, is the substitution of a cylinder of compressed air or compressed CO_2 for the acid bulb arrangement and chemical action as the motive power for the "first-aid" jet. This has the advantage that the whole of the water in the tank need not necessarily be ejected, should it not be all required for the extinction of a small fire—the tap admitting the gas or air being shut off whenever desired.

In motor steam fire engines a "first-aid" jet, through a small hose similar to that of a chemical engine, has more recently been provided for by fitting a small-sized auxiliary steam pump in addition to the main pumps, which takes its supply from one of the ordinary tanks on the engine until the main pumps or a hydrant be set to work. This arrangement is, of course, rendered practicable by the fact that the steam motor arrives at its work with full boiler pressure available.

Hook Ladders.—Reverting to the subject of life saving, increased attention has been drawn of recent years to the means of access to exceptionally high windows, or to those too high to be reached by scaling ladders or ordinary ladders which overlook gardens and other enclosed places inaccessible to an ordinary wheeled fire escape. The hook ladder—an adaptation in ladder form of the method of scaling a height by throwing up a light grapnel and climbing up the rope attached thereto—had been in use on the Continent and in America for many years (since the early part of the 19th century). In those countries it had been preferred to the wheeled escape, largely on account, in the former case, of the existence of narrow streets and courts too cramped for the working of the latter, and in America on account of the abnormal height of many buildings.

The pattern adopted largely in England is two-sided, with a single hook that folds down flat on the ladder for convenient stowage. This can be carried loose, in place of a "first-floor" ladder on the main ladder of the ordinary fire escape, and is used either from the top of the latter for reaching exceptional heights, or in such enclosed places as I have mentioned.

It may also, with its hook folded down, be used as an ordinary light, short ladder, and is, in skilled hands, a useful auxiliary appliance. The head of the ladder is made to rise a short distance above the position of the hook, so that it affords the fireman some hand hold when starting to descend—an important point.

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It is obvious that ordinary untrained persons cannot make use of these hook or "Pompier" ladders, and therefore, wherever practicable, the ordinary telescopic escape is the more convenient appliance, and enables a "rescue" operation at a fire to be carried out more easily. A canvas shoot may of course be used in conjunction with the "Pompier" ladder in some cases—being drawn up by the firemen after they have scaled the required height, and taken up a firm position—but, on the whole, "Pompier" ladder work is more or less risky, and requires good training and selected men to get the best results.

Very useful light telescopic ladders reaching to a height, when extended, of some 35′, and specially braced for strength and stiffness, are now made for use in enclosed gardens, etc., being carried overhead in some first-aid machines, in preference to the larger wheeled escape. These are very suitable to residential districts where there are many villas of moderate height surrounded by garden walls. With the addition of one or two lengths of hook ladder and a skilled detachment of firemen, the equipment will meet most cases likely to occur in such localities.

Introduction of Steam Fire Engines.—The steam fire engine, though its general adoption in public fire-brigade work did not commence till the early "sixties," is an invention of earlier date than is often remembered. I am indebted for the dates mentioned below to Mr. Young's exhaustive historical work on "Fires, Fire Engines, and Fire Brigades," which gives a complete account of the subject up to the date of its publication some years ago. It may be of interest to note that as far back as 1829, Messrs. Braithwaite and Ericsson built a serviceable horse-drawn "steamer," burning coke and having a boiler similar to their "Novelty" locomotive which competed with Stephenson's "Rocket." This engine, though slow in raising steam in comparison with its modern successors, did good work, but it seems to have been in advance of its time in Great Britain and was not adopted by the fire authorities in London, (possibly owing to indifferent water supply in the streets) in spite of its success. Engines of this type, however, were made for Liverpool and Berlin, and appear to have given satisfaction.

In America a self-propelling steam fire engine was built as early as 1840 in New York, and another in Cincinnati in 1853, and in the "fifties" the steamer was coming into use in various American cities, including Baltimore and Richmond, Va. (1859). The first land steamer was used in the London Fire Brigade, (then called the "London Fire-Engine Establishment"), in 1860, and from that time its introduction gradually spread at home and abroad.

Motor Engines: Their Advantages.—About the year 1900, Messrs. Merryweather produced the successful self-propelling steamer known as the "Fire King." This has had universal success in many

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countries, and is still preferred by some authorities to the more recent petrol motor pump for long-continued heavy pumping jobs. The oil-fired steam motor engine has one great practical advantage in that on return to its station there is the minimum of trouble to the station staff, *i.e.* no boiler fire to rake out and re-lay ready for another call, (perhaps a "false alarm" an hour or two later in the night to be followed by the same trouble for nothing), and no horses to attend to—the oil fuel being shut off and the gas or other heater re-connected the engine is ready for duty again at once.

The petrol engine has, of course, similar advantages, and requires no heating to be maintained. All motor fire appliances, if fitted with suitable power, have the advantage over horsed machines that they can carry a strong crew of men without considering the overloading of horses on long or hilly journeys.

Modern Steam Fire Engines.—The ordinary patterns of steamer being still likely to remain in use for many years, and being also an appliance useful to Engineers for emergency pumping operations; such as camp water supply, waterworks breakdowns, etc., it may be of some use to give a short notice of the leading types.

Types of Engine.—The modern steam fire engine is, except in its smallest sizes, very generally of the double-cylinder vertical type; *i.e.* two steam cylinders and two pump cylinders vertically below them, with the pistons of each couple rigidly connected. An intermediate crank shaft to give motion to the eccentrics and slide valves and regulate the stroke is actuated either by "return" connecting rods or by slotted links. This vertical type, with the machinery placed at the back of the boiler, is exceedingly convenient for allowing access to the working parts. The horizontal type of engine, however, with the machinery fixed between the main frame of the carriage in front of the boiler, leaves the back of the latter absolutely clear for the work of stoking.

Stoking Arrangements.—Much discussion and difference of opinion has arisen about the relative merits of the rear or side position of the fire-box door, and of "rear stoking" as compared with "side stoking." Engines of the vertical type alluded to above, if the crank shaft is driven by connecting rods, naturally occupy rather more vertical space than if the slotted link action is employed; in the former the fire-box door is placed at the side of the boiler, and when the engine is stationed for work the fore carriage is locked round to give more room for the stoking operations. The inlets and outlets of the hose can be placed at a low level above the ground, and the stoker is out of the way of those attending to the machinery and connecting the hose. On the other hand, the fire cannot be stoked or attended to while the engine is travelling, and it is therefore very important that it be skilfully laid, and lighted up if not, as in short runs, at starting, at the right time on nearing

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the scene of action. The lighting up may be accomplished, if desired, by a patent apparatus, and the fuel effectively kindled while travelling.

In a "rear-stoking" engine there is the facility for giving attention to the boiler fire while on the road, and the adoption of the slotted link action for turning the crank shaft, as in Messrs. Merryweather's "Gem" type, enables the machinery to be made compact enough for the fire-box door to be placed beneath it at the back of the boiler.

On the foregoing question it may be said that both classes of engine are in extensive and successful use, and that it is for intending purchasers to weigh their relative advantages.

Older Types.—Of earlier types of steamer now being supplanted by the modern ones alluded to above, two famous designs may be named. The first of these is Messrs. Shand and Mason's "Equilibrium," a vertical engine with three steam and three pump cylinders, the action of which is regulated by a crank shaft as in the "double vertical," with three cranks set at an angle of 120° with each other. Great power combined with steadiness of running is obtained in this type. The second, another most notable class which has done good service during the last 40 years, is Messrs. Merryweather's "Twistbar" machine; a horizontal slow-stroke engine without crank shaft or fly wheel, the steam valves being actuated by means of the partial rotation to and fro on its own axis of a twisted steel bar or shaft paralliel with the piston rod and rotated by the forward and backward motion of a kind of claw attached to the latter. Very powerful engines of this class have also been made with double cylinders.

Hand-Drawn Steamers.—For the protection of small "risks" where, as in a factory, private residence or institution, only a limited area has to be traversed, small hand-drawn steamers of the "Valiant" and similar types are light and useful: they have, as a rule, a pumping capacity of from 100 to 200 gallons per minute, and may stand on their own base when at work—the carriage being detachable or be fitted on four wheels.

These very small steamers are sometimes mounted on a horsed carriage for the requirements of village and private brigades. Where an engine of this kind is mounted only on a "skeleton" hand carriage, it is important to provide a suitable handcart or truck to accompany the engine, and carry all the needful coal, hose, tools and small gear. These, otherwise, are liable to be mislaid or forgotten, especially in the dark, and some good lamps, it need hardly be said, are also essential.

Accessories.—Makers of fire engines supply with their machines a complete list of the accessories required for working. Among the most useful fittings may be named the "breeching"—or **Y** connection—enabling a line of hose to be divided into two, for supplying two jets from one hose, or for combining two streams into one

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"branch" and nozzle. With steamers the friction in the hose can be greatly reduced in this latter manner, where the whole power of the engine may be required to be concentrated into one nozzle of large diameter for the purpose of throwing a specially high and heavy jet. Two lines of hose from the two delivery outlets fitted to an ordinary medium-sized engine are sometimes united in this way by a breeching, this method of working being termed "Siamesing." The power of two manual engines of similar capacity can in the same way be concentrated into one large nozzle for exceptional purposes, this mode of working having been a necessity in old days before steam power was available, when a specially heavy jet was required.

Water Towers.—Of other recent appliances much has been heard at times of the "water tower." In America these special appliances (necessary for dealing with exceptionally high buildings) consist of a horse-drawn carriage carrying what may be termed a "portable rising main," having a large nozzle capable of being raised to the level of the fire and directed from below by suitable gearing. The power of two or more engines is concentrated in the "tower" by separate hose inlets. A less elaborate arrangement, attached to the ordinary long fire escapes, has hitherto been found sufficient for the more moderate-sized buildings found in Great Britain.

High-Pressure Water Systems.—A special high-pressure hydrant system has lately been adopted in New York, and may be called a valuable auxiliary, but any underground water system involves the risks of a partial failure through unforeseen accident or bursts, and it is unlikely that portable fire engines will ever be dispensed with with safety. In any case large heavy vehicles will always be necessary to carry the firemen and hose to their work.

Value of Floating Engines.—In conclusion, brief mention may be made of the experiences deduced from the great fires that have followed recent disastrous earthquakes, of which not the least noticeable is the advisability of the provision, where practicable, of floating engines or "fire boats" which, unless some altogether abnormal upheaval of the sea bed takes place, will often be able through long lines of hose, to render valuable aid from the sea or river, after the ordinary water service of a city has been totally dislocated. Large, heavy land "steamers"—sometimes found obsolete for fast travelling—may similarly, if kept near the water side, form a useful reserve in case of disaster, owing to their great power and range of action uphill as well as on the level. The expenditure allowed for their upkeep may under such circumstances, be recovered many times over, by the value of the property saved from destruction.

Since the completion of the foregoing paper a Report of great interest dealing with recent progress in fire brigade work in Berlin,

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Hamburg, and Hanover, has been published by the British Fire Prevention Committee as No. V. of their Journal. This also gives information on fire-resisting construction in warehouse and other buildings in the cities named, and contains a number of valuable diagrams and illustrations.

My previous remarks have chiefly referred to British fire appliances, and a few points in German practice as described in the above Report may be briefly alluded to, as showing a similar advance in matters of motor traction, etc. :—

(*a*). The adoption of large motor chemical (or CO_2) engines, taking the place of the old manual and water cart for the first attack.

(*b*). The importance attached to hook-ladder work in addition to the increased use of long telescopic ladders, many self-propelled.

(*c*). The introduction of self-propelled steam fire engines, some with electric traction, others travelling under their own steam.

(*d*). The careful study beforehand of the best methods of attacking fire in important buildings.

The authors of the Report in their Introduction make a notable point in suggesting that fire brigades dependent chiefly on motor appliances should include at least two classes of motor traction among their vehicles, so that failure of either electricity supply, or of stores of oil fuel or of petrol, such as may occur during strikes or in war time, should not deprive the brigade of all their means of traction at one time.

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RECENT DEVELOPMENT IN ROAD MAINTENANCE.

A Lecture delivered at the S.M.E. by H. P. MAYBURY, ESQ., M. INST. C.E., *Kent County Surveyor, and Member of the Advisory Committee to the Road Board.*

THE subject of our roads is one which has, since the passing of the Motor Car Act of 1903, received perhaps more attention than almost any other engineering problem.

From the time of the railway boom, in the middle of the last century, and for 50 years thereafter, the roads of the country were thought to be of no national importance and were handed over to various local bodies to supervise and maintain, often with disastrous results. A local farmer was elected as surveyor and contractor for the upkeep of a few miles of roads through his particular parish. As ruts appeared, so a few pebbles were picked up off the land and laid in them indiscriminately, and these the traffic had to consolidate. Very soon the roads became quite unfit in the sense of being really ways for traffic. No better proof of this could be found than in the fact that wherever military manœuvres took place on a large scale —as at Salisbury Plain in 1872—at the end of a week, the wheeled traffic had turned the roads into a quagmire, through which men and horses dragged their weary way, the marching powers of both being practically exhausted by a mileage of not one half the distance they would have been able to accomplish without fatigue, upon roads well and efficiently maintained.

The passing of the Local Government Act of 1888, by which County Councils were created, saw the advent of a new order of things. In most counties, trained and qualified Civil Engineers were appointed to act as Chief Surveyors, the result of this scientific and skilled management being that in the 15 years to 1903, the date of the passing of the Motor Car Act, a vast improvement had been effected. The question of finance was in this as in everything else in this world, the all-important one. All expenditure had to be met by local taxation, and it was (as it is now) always more popular to strive for economy rather than efficiency.

Although the highway authorities of the county have been much abused for the condition the roads were in, in 1903–4, I am inclined to think this abuse was most unjust. Until 1896 the maximum speed permissible on any of our highways for any self-propelled vehicle was 4 miles an hour, and then such vehicle had to be preceded by a man carrying a red flag. In that year, 1896, self-propelled vehicles of

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certain defined weights were allowed to travel at a maximum speed of 12 miles an hour, but very little advantage was taken of this altered condition of things, as at the time of the passing of the Motor Car Act (1903) it is estimated that there were not more than 1,000 self-propelled vehicles (other than traction and agricultural engines) in the United Kingdom, whereas by the end of the following year (1904) 51,549 motor cars and motor cycles were registered. The road engineers were not advised that this altered form of traffic might be expected. The revolution came upon us with as little warning as the British will receive of the invasion of the country, which certain alarmist journalists tell us is bound to occur at an early date. Parliament, in giving the self-propelled vehicle its charter of freedom, did not stop to enquire what effect it would have upon the roads. One cannot imagine an entire change in the rolling stock of one of our important railways being contemplated save in conjunction with the consideration of the capabilities of its iron roads and bridges to support and satisfactorily carry same. Before increasing weight or speed the railway engineer would have reported to his Board upon the strengthening of the permanent way necessary, and such works would have been undertaken before any alterations in the Company's regulations were sanctioned. How different in this case. The new traffic is legalized, and the several local governing authorities are expected to find out precisely what is best to be done to meet it, and also to provide *from the rates* the money with which to carry out the necessary improvement works.

Officers in charge of the roads under such conditions are entitled to sympathy rather than the abuse which from time to time is showered upon them by irresponsible persons. The various local governing authorities so little appreciated the necessity for increased expenditure that it was extremely difficult to get any additional sums voted; the result being that for the first year or two (*i.e.*, to 1905) the surfaces of the roads of the country seriously deteriorated.

In the County of Kent the problem became peculiarly embarrassing. For many years large quantities of the local ragstone and flints had been used, the greater part of the London and Dover Road being surfaced with those materials, which, pulverized as it soon was by traction engine traffic, raised the dust question in an acute form. I well remember in the summer of 1904 employing all the men I could get with buckets and brooms to collect the dust from the road surfaces and put same in heaps on the wastes adjacent. Having the direct charge of about 600 miles of main roads upon which each year up to 1903–4 some 50,000 cubic yards of ragstone and flints had been used, I soon saw it was hopeless to attempt to maintain the roads for the then traffic with the local material available, and in the following year my Council voted such a sum as enabled me to procure 74,000 tons of hard stone, such as syenites, basalts, whinstone and

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granite. As this quantity was only sufficient to metal about an eighth of the whole, it was necessary that whilst improvement was made with this hard material, local stone in large quantities should still be purchased and used for urgent repairs. In addition therefore to the quantity of granite aforementioned, some 25,000 tons or yards of flints were obtained and used. Traffic continued to increase in volume, weight and speed, to such an extent, that even with the better material one could achieve little or no progress, but, thanks to an enlightened council, who consider efficiency with economy, a larger annual vote has been made, so that in the year ended the 31st March last I was enabled to purchase and actually use upon the 600 miles aforementioned no less a quantity of material than 128,504 cubic yards, or tons equalling 215 tons or yards to each mile, the cost of stone alone being upwards of £50,000.

The length of through roads in England and Wales maintained by funds derived from rates is 123,556 miles, 27,638 of which are main roads. The cost of maintenance in the year 1909 was nearly 4¾ million pounds sterling. This sum does not include the expenditure of Boroughs and Urban Councils in the maintenance of purely local streets. The total mileage of roads in the United Kingdom in 1906 is given as 228,439. The cost in *that* year being 15½ millions, *now estimated to be 20 millions.* Self-propelled traffic continues to increase at an amazing rate. As already stated, in December, 1904—a year after the passing of the Motor Car Act—there were 51,549 light motor cars and cycles registered, whilst in December, 1909, these had increased to upwards of 190,000. Under the provisions of the Motor Car Act the Local Government Board was empowered to make regulations for the inauguration of the heavy or commercial motor. Such regulations were issued in 1904, and as a result we have (*a*) the steam motor lorry; (*b*) the steam motor tractor; (*c*) the petrol commercial motor. No complete statistics are available as to the numbers of these vehicles registered in England and Wales, but we know that in one year more than 6,000 were registered in London alone. There are 8,600 traction engines licensed.

With this revolution in the traffic using the roads it became imperative that different methods of maintenance and repair should be adopted. Given any one kind of vehicle, it is comparatively easy to meet the case, but it is by no means so to maintain one road to suit all. The light motor car moving at a high rate of speed could be economically served by the laying of a comparatively thin coating of hard material upon existing surfaces, treating this with a tar compound, and renewing same as became necessary. The smoother and more polished such surface became the smaller the cost of maintenance and the more economical, both in tyres and petrol, the running of the cars. Such a surface, however, would neither be suitable for horses nor for the iron-shod wheel of the commercial

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motor and traction engine, consequently, the road engineer has had to adopt such measures, imperfect no doubt, but still fairly effective to suit all users.

Perhaps the most obvious defect in our roads is the insufficiency of their foundations. If cost were of secondary consideration, the engineer would strengthen the foundation of his road in the most up-to-date manner, and then lay on his coating of hard material or tar-macadam, taking care to make the surface as impervious as possible, so as to keep his foundation and road bed dry and unyielding. Since the days of Telford and Macadam, numerous textbooks have explained to engineering students how to construct a road, by putting in a solid foundation of hand-packed stone of large size, on which the surface metal should be spread. Unfortunately, even after the lapse of several generations, this desirable method is still almost entirely confined to textbooks.

The cost of so dealing with our main trunk roads would be enormous. A few years ago, the County Council of Hampshire, in conjunction with the War Office, proceeded to reconstruct some 10 miles of road in the vicinity of Aldershot. The road bed was formed to the proper curvature, and upon this, large blocks of limestone were laid, varying in thickness from 6″ at the haunches to 14″ in the centre. Upon this 4″ of Rhenish columnar basalt was laid and consolidated. The cost of this work was close upon £20,000. It will be seen, therefore, that to deal in the same way (which is the textbook and no doubt the proper method) with the 27,000 odd miles of *main* roads in England and Wales would mean an expenditure of about 55 million pounds. As any such sum or even a third of it, is quite outside the range of practical politics, the road engineer has to satisfy himself by providing foundations by "accumulation," that is to say he endeavours, and invariably succeeds in laying down a little more material than is actually worn out, and so gradually,—very gradually, I fear, in some counties,—accumulates a support to his road, in the hope that at no distant date it may be of sufficient thickness to transmit the imposed load to the weaker subsoil, and so avoid the crushing through of the surface. It has been estimated by a reliable authority that to provide for ordinary wear and tear, and for an accumulation of 1″ of thickness of surface only, over the main roads would mean an additional expenditure of 9 million pounds. If the foundation and subsoil, and the accuracy of cross fall be matters of great importance, equally so of course is the metal comprising the surface. For many years past road engineers have been making practical experiments in their endeavours to determine the relative values of the various materials available, and whilst I agree and recognize that experiments made in laboratories are valuable, still the results are not as trustworthy as those made under actual working conditions. So

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much depends upon the nature of subsoil and upon the effect of atmospheric influences upon same. Whilst excellent results may be obtained with one kind of stone, say upon a chalk foundation, these may be extremely bad if the same material were laid upon yielding clay. Although it has been possible to obtain reasonably reliable information from the many experiments made, it has not been practicable to determine, in figures, the influences of subsoil and climate. As almost every district produces a stone of some description which has a certain value for foundation purposes; in the south-east of the country there are no volcanic rocks, and therefore we have to go very far afield to secure hard material.

The columnar basalts of Germany, the syenites of Belgium, the quartzites of France and the granites of Norway, in addition to those of the British Isles have been drawn upon to an enormous extent, and if we are to have strong, smooth and comparatively dustless and durable surfaces, still further tribute must be exacted. Here again it is difficult to determine relative values. The hardest material is not necessarily the best, in fact its hardness is often found to be a disadvantage. A very hard material is often an extremely difficult one to keep compact and tight. Again most of the basalts when broken by machinery have a tendency to flake, whilst a softer though tougher material breaks cubical. The result, in practice, is that the softer material is much more cementitious, keys together under the action of the roller and withstands the concussion of the high-speed self-propelled vehicle better than the harder, but less compact, surface. Even with the abandonment of the limestone and flint for surfacing, and the use of the imported hard stone, the dust nuisance, although minimized, is by no means effectively dealt with.

We have on the roads two very distinct kinds of dust; first that the result of the animal traffic, which is the most offensive, and secondly that which is due to the wearing of the road material, either on the surface directly under the traffic, or in the core of the road caused by attrition or rubbing of the stones by movement due to the loads passing over, and which dust works to the surface together with mud from a wet subsoil where the foundation and road crust is insufficient to prevent it. It has always been realized that excellence of construction goes far to reduce wear, and, therefore, to reduce dust and mud, still it has been fully understood that it does not by any means prevent it. Dust we have always had. It was a great trouble to our forefathers. The numerous pumps on the old Bath and other roads will bear witness to this, but as in our time watering to keep down the dust has been found to be impossible, we have had to resort to other methods. In 1856 Claus proposed to use a solution of calcium chloride or magnesium chloride for dust abatement, and in 1867 a Mr. and Mrs. Cooper were granted a patent for the use on

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roads of a solution of common salt with chloride, such as calcium or magnesium. We have to-day in many counties the use of large quantities of calcium chloride, which is a by-product from the manufacture of alkali, and which is available at a nominal price at the works of Messrs. Brunner, Mond & Co., Ltd., in Cheshire. It can be, and is being applied to the roads both in liquid and in dry granular form. This material is doubtless an excellent palliative, but the measure of its value is entirely one of atmospheric conditions existing at the time of its application. At the request of Messrs. Brunner, Mond & Co., the Roads Improvements Association in 1909 appointed a Technical Committee to make experiments with, and to take observations from, the use of calcium chloride. I had the honour of serving on that committee, which was composed of three Engineers and a Fellow of the Institute of Chemistry. Extensive and prolonged tests were made in Middlesex and Cheshire. The report of the committee was, that whilst the use of this chemical was less injurious to ordinary roads than the watering now necessary for the effective abatement of dust would be, yet it was of little or no value to road maintenance, and when extensively used under bad climatic conditions, it produced a glutinous mud, which adhering to the wheels of vehicles, had the effect of pulling up the granite surface, thus accelerating disintegration. The cost of the use of calcium chloride obviously depends upon the amount of freightage to the point of user. In Cheshire, it is returned as a fraction of a penny per super yard, whereas in Worcestershire the cost is given as 1d. per yard, or from £40 to £60 a mile.

It is generally conceded that the nearest approach to the ideal road is obtained by the use of some bituminous material in some form or other. As long ago as 1834 one Cassell aroused a good deal of interest at the time, and has doubtless been the source of inspiration of numerous subsequent efforts. Cassell's specification, amongst other things, provided for the saturation of the road bed with oil obtained by the distillation of tar, and then coating it with tar, which he set on fire, extinguishing it by applying slag, cinders, etc. These he rolled into the heated tar, and he went on to specify that the efficiency of the cemented layer might be increased by adding other layers of tar and grit. This he provided for covering with broken metal, the interstices being grouted or run in from the top with distilled hot tar and sand. When this was cold Cassell applied a thick coating of distilled tar mixed with sand, etc. He then consolidated the whole. In 1883 Mr. Leopold Stiebel, of London, proposed a similar method, but with asphalte as his matrix. In 1890 Messrs. Hirsch and Reinisch applied for a patent for a similar method, but using ground stone and pitch as their binder.

In 1902 a Mr. F. J. Warner, an American, patented in England what he described as a "bituminous material road," which is identical

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with the system of which a year or two ago so much was heard, and which was described as the "Gladwell" method. As, doubtless, most of you know, this system provides for the laying upon the old surface of a thickness of from $\frac{3}{4}$" to $1\frac{1}{2}$" of granite chippings, mixed with tar, upon which the metal is imposed, the idea being that the passing of the steam roller over same induces the matrix to work up and fill the voids between the stones. After sufficiently rolling, a layer of the same matrix is spread on the surface and rolled, this being supposed to make the whole impervious and hard. Very little indeed is heard of the process to-day. In practice it was found not only extremely costly, but under heavy traffic it was impossible to keep it from moving, the tar in the bottom matrix acting as a lubricant, keeping the whole alive, with the result that a wavy and irregular surface was soon in evidence. A section of a main road in this county between Erith and Crayford was laid in accordance with the "Warner" or "Gladwell" specification, at a cost of about 2s. per super yard. The result was not sufficiently attractive to warrant an extension of the process.

About 1902 also; Mr. E. P. Hooley, M. INST. C.E., the popular County Surveyor of Nottingham, patented and introduced his method of coating slag macadam, etc., with a mixture of tar, pitch, Portland cement and resin, and which is so well known to you under the name of "Tar Mac." This is an extremely simple and comparatively inexpensive material, and in the vicinity of iron works where blast furnace slag is produced, and is a waste product, it has immense advantages. The slag, in a molten state is run into iron trollies where it solidifies. It is then tipped from the lorry on to the floor of a covered shed, and sledged up to sizes capable of being fed into a stone-breaking machine. In this it is reduced to proper macadam sizes, afterwards being sorted by revolving screens. As it leaves the screens for the respective storage hoppers, it is met by a spray of heated tar compound. From the storage hoppers it is loaded direct into railway trucks or carts, and is ready for use. It will be seen therefore with what an immense advantage tarred slag starts its commercial career. There are no quarrying costs, and no drying or heating, and therefore small labour charges for handling. The greatest cause for wonder is that only a small quantity, comparatively, has yet been used. One of the works of the Tar Mac Company was at Denby near Nottingham, their chief works, however, are at Ettingshall, Wolverhampton. Notwithstanding the geographical positions of the works, only a small portion of the main roads of the county of Nottingham have been coated with "Tar Mac," whilst the county of Stafford, of which Wolverhampton is the "hub," has hardly deemed it worthy of trial, preferring instead to purchase the excellent basalt as supplied from the south Shropshire quarries, known as Clee Hill. Railway carriage makes the use of the Wolverhampton product prohibitive in the neighbourhood of

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the Metropolis and south thereof. A short section of main road laid with "Tar Mac" can be seen in the village of Wateringbury in this county, but as the material cost about 20s. a ton, let it be never so good, it is quite outside our financial possibilities. Let me give you an example:—The railway carriage for "Tar Mac" from Wolverhampton to Maidstone is 11s. 6d. a ton, the covering area of which quantity would be about 10 super yards. Add this to the cost of the slag preparation which would be from 7s. to 7s. 6d. a ton. Say 18s. a ton at Maidstone or equal station. Now compare this with say Belgian syenite. This latter is delivered at Maidstone at 9s. 6d. per ton, the covering area of that quantity being from 11 to 12 super yards. The haulage, labour and rolling charges for each would be much the same, so you will see that "Tar Mac" would cost, laid complete, at least 1s. per yard super more than syenite, or assuming 10,000 yards to the mile, say £500 per mile in excess. For £60 per mile the syenite road could be treated with two coats of heated tar compound making it almost as impervious as, and quite as dustless as the "Tar Mac." Apart from cost, "Tar Mac" has one decided disadvantage, wearing as it does extremely slippery, and being very hard, animals of all kinds experience much difficulty in obtaining a foothold. For rubber-shod self-propelled traffic, a "Tar-Mac" road is ideal, there being very little dust in summer and an absence of mud in winter. What, doubtless, *has* retarded its use, has been the general weakness of the foundations of the roads, the engineers being of opinion that they would be courting failure by laying expensive materials, which might be sheared through by traction engine traffic in consequence of insufficient vertical and lateral support.

Again, before using impervious material, it is necessary to raise the sides or haunches, in order to flatten the cross fall of those roads which may have a camber suitable for ordinary untreated macadam. The cost of these necessary improvements to foundations and cross fall on the main roads only of England and Wales is so vast, that even if the cost of providing the impervious surface was much less than it is, there are no prospects at present of finding the funds to enable the works to be carried out upon a large scale.

There are many other proprietary articles made in more or less the same way as "Tar Mac," the difference being that granites or syenites are used instead of slag, but like "Tar Mac," unless such material can be produced in the neighbourhood near which it is required to be used, their costs are prohibitive. Two of these proprietary materials are known as "Tarlithic" and "Quarrite." Samples of both can be seen in this county, some of the former having been used in the Borough of Gillingham, whilst a section of the latter has been laid on the road inside the confines of the Cavalry Barracks at Canterbury.

The county of Kent has always been noted for its ragstone tar paving which has been extensively used for many years past in the

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coast towns for sea front promenades and footpaths; for the paving of school playgrounds, railway station platforms, etc. The abolition of the use of the Kentish ragstone as road metalling, seriously affected an established county industry, and threw upon the unemployed labour market a large amount of unskilled labour. The ragstone quarry owners are now engaged in endeavouring to regain the ground thus lost by manufacturing tarred macadam for main road requirements.

For the last year or two experiments have been made with this material. Some three years since a section of the London-Folkestone Road was placed by the County Council at the disposal of one of the manufacturers, an agreement being entered into by which for an annual payment for each of five years the contractor laid with tarred macadam and maintained same to the satisfaction of the County Engineer. This section has not been an unqualified success, but as a result of the experiment it was discovered how to improve, and about 14 months ago a longer section—1¼ miles—on the London-Hastings Road between Bromley and Sevenoaks was laid with the same material. This *has* been a success up to the present, and so satisfied was my committee with it, that in the present year we placed orders with the several manufacturers in the county for 20,000 tons. I suppose about half this quantity has now been laid upon all kinds of subsoils and varying strengths of foundation. Kentish ragstone, although softer than slag, has the advantage of giving a better foothold for horses. It is essential, however, that it should be treated as soon as laid, with a good covering coating of heated tar compound, and if clean sharp angular grit or granite chippings be applied whilst the tar is hot, an excellent wearing surface is obtained. Close attention has been paid to these tarred macadam surfaces, and the moment the ragstone has shown signs of abrasions, another coat of tar and shingle has been applied. Although the ragstone is quarried and treated in the county, it is still at a financial disadvantage with imported hard material to the extent of about 3d. per super yard, or £125 per mile, and therefore it must be more durable in order to justify a substantial extension of its use.

We are now engaged in making experiments with flints treated in exactly the same way as the ragstone. A section of about ½ mile will shortly be laid with this "tarred flints" in the Isle of Grain, and a second section will be laid on the main road between Gravesend and Wrotham.

Again, another experiment is being made in the preparation of another tarred macadam, the material being shingle, from the beach. This shingle is burnt in a brick kiln, the pebbles by being subjected to the heat bursting and becoming angular in shape. Upon being taken from the kiln, the shingle is screened so as to remove the dust, and whilst warm is treated with freed tar. A short section of road has been laid with this material about midway between Rye town

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and the harbour, and at this moment a short section of the county main road is being laid with it between Hythe and Appledore Should this latter process be a success—and I am hopeful—there is no limit to its possibilities, as the shingle can be procured for a few pence per ton.

Various other experiments have been and are being made upon the county main roads. Quite recently, in July last, a section of the London-Folkestone Road, some 2 miles west of Maidstone, was treated as follows :—The surface, a granite one, was scarified, the old material being removed. Upon the formation thus prepared a layer of 2¼ Belgian syenite granite was laid and rolled as tightly as possible, dry. Various grades and qualities of bituminous binders were purchased and used in grouting in defined sections. These binders, which are delivered in solid block form, are melted in large boilers, the liquid being poured from lipped buckets into the interstices of the road surface, the quantity of the binder required being about half a gallon per super yard. Whilst the material is hot, sharp washed angular grit or granite chippings are applied and the roller passed over. The whole section was subsequently treated with a top dressing of heated distilled tar, when more clean grit was applied. The cost of this work has been about 2s. 10d. per super yard, much the same as that of "Tar Mac," and considerably less than "Quarrite" or "Tarlithic." It cannot fail to be superior in wearing properties to "Tar Mac" because the material is an excellent syenite road stone as compared with what, after all, is only a blast furnace cinder. Another short section on the same road, but east of Maidstone, has been laid in the same way, the grouting and binding material in this instance being a preparation known as "Roadoleum," which is a by-product from the refinement of petroleum, and is supplied by the Anglo-American Oil Company. This material works freely and well, and gives good promise, but whether it would ever be obtainable at reasonable and comparative prices I have no means at present of ascertaining.

Another experiment with the same material applied in precisely the same way is to be made close to the boundary of the Metropolis and where the road, in addition to supporting the heavy traffic between the county and London, has recently had imposed upon it the additional burden of a frequent motor bus service from Sidcup to Oxford Street.

The permanent value of these experiments time alone can decide. I have said enough thereon I am sure, to show you that at all events the County Council of Kent is alive to its responsibilities, and is determined to be in the van with its roads, as it is with its cricket and its territorial forces. It is conceded, I think, by persons competent to express an opinion, that, taken as a whole, at the present moment the main roads of this county are second to none.

If this be true, and I know it to be so only by comparison, I assure

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you, it has not been attained without the expenditure of large sums of money, *all derived from the rates*, and the continuous labours and perseverance of the Council's technical staff. We have used large quantities of local materials to strengthen foundations and reduce camber, have procured and laid upon same the best and toughest material to be obtained, have consolidated same in the best known way, and whilst the surfaces were yet good, dealt with the dust nuisance and made the roads impervious by repeated coatings of heated tar. To give you some idea of the magnitude of this latter work. In the year ended the 31st March last, the tar-painting bill alone came to nearly £16,000, about 650,000 gallons of tar having been used in coating 303 miles of surface. In the present year, we set out to use a million gallons of tar, and I do not think when the returns are received from the several divisions we shall be very far short of having accomplished this.

Other counties are doing more or less in this direction, Surrey and Middlesex (both now being comparatively small counties), having treated practically the whole of the surfaces of their main roads with tar on granite or syenite.

In addition to creating the necessity for improvement in the surface of the road, the self-propelled traffic has put upon the local governing authorities still further responsibilities, such as the reconstruction and strengthening of bridges and culverts, the provision of footpaths for pedestrians, and the improvement of dangerous corners. In the year ended the 31st March last the expenditure upon such works was close upon £10,000. The total main road bill of the county for the last financial year was £154,263 for maintaining and improving 750 miles of main roads, made up as to 580 in rural districts and 170 in boroughs and urban districts, this expenditure being equal to a charge of about £206 per mile.

The bridge question is a very important one, closely allied and inseparable from the roads, because as we know the chain is no stronger than its weakest link. From a national and military point of view all bridges under roads should be capable of supporting the heaviest load legally allowed to be upon the roads. For instance a traction engine empty may weigh 16 tons, and this, when carrying its complement of coal, water and tools may easily touch from 18 to 20 tons. A road authority is not required by Parliament to have its bridges sufficiently strong to support such traffic, but may by notice prohibit its passage over a particular bridge. Public opinion, however, is generally sufficient to influence County Councils to strengthen, but this has no effect upon companies trading for profit, whose canals or railways honeycomb the otherwise continuous highway. Many anomalous structural conditions have been revealed by detailed inspection of a large number of highway bridges. It has been by no means unusual for instance to find that a steel bridge has its main

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girders of ample cross-sectional strength for carrying heavy traffic, whilst its cross girders have proved to be quite inadequate to bear concentrated rolling loads. Such conditions show that the bridges have probably been designed by draughtsmen who, in order to save trouble, have based their calculations upon loads per square foot *dead*, rather than upon rolling loads combined with dead weight, and some few cases have occurred where the reverse condition as to girders has been shown. A case in point was one quite near to us. In 1856 a Railway Company obtained powers to construct a railway from Sittingbourne to Sheerness, and in connection therewith to construct a bridge—King's Ferry—over the Swale. Plans were deposited with the Board of Trade, and approved by that department, the bridge being constructed strictly in accordance therewith. Although by the defect in the design of its cross girders, the bridge was never theoretically capable of supporting traction engine traffic, yet by the laches of the Company's officials, road engines were permitted to cross, with the ultimate result that an engine fell through into the Swale. As the Company was only required to keep the bridge up to the standard existing at the date of its construction 1856, which was in pre-locomotives on highway days, a notice was erected prohibiting all traffic having a load of 5 tons and upwards upon four wheels. The result of this prohibition was to shut off the Isle of Sheppey from the mainland, so that no agricultural engine for ploughing or threshing purposes could be taken in, nor could a heavy motor car cross. This appeared to the County Council to constitute a great injustice to the agriculturists in the island, placing them at a disadvantage with their neighbours on the mainland. Negotiations were, in consequence opened with the Railway Company with the result that an agreement was arrived at, subsequently consolidated by Act of Parliament, by which the County Council contributed in kind between £1,400 and £1,500 towards the strengthening of the cross girders, so as to enable heavy traffic to get into the island. This work was accomplished during 1909, and the restrictions imposed are consequently a thing of the past. The law at present only requires owners of private bridges to maintain them to their original standard of strength.

Many railway bridges under the roads in this county are suffering from the defect of inherent weakness, and most people have seen, I suppose, on such bridges, notices intimating that the bridge is only equal to —— tons. Of what use would such bridges be in the event of a national emergency ?

Gentlemen who are responsible for transport of heavy guns, ammunition, and for the Commissariat Department may find when the enemy has arrived at Dover that the bridges are down, not by the enemy's depredations, but because a transport locomotive has fallen through on to the railway.

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An endeavour has been made by the Traction Engine Owners' Association, by that of the Commercial Motor Users, and by County Councils to impress upon the War Department the extreme importance of remedying matters, but so far as I know, with little or no result. There are certain advocates of an amendment of the law which would compel railway and other companies to strengthen their bridges *pari passu*, with increasing traffic. This is a gospel of perfection which would not be acceptable to any Parliament because it would be unjust to the trading companies.

It should be possible, however, for an enquiry to be held by, say, the Local Government Board, upon the representation of any Government or local authority, or by any body of aggrieved persons, and the Local Government Board should have the power to order that a bridge should be reconstructed in such a manner as to be capable of supporting present-day traffic, with an ample margin for future development, and that the cost of such reconstruction should be borne in such manner as a qualified engineering arbitrator, appointed by the Board, should determine. As the trading company would receive some betterment by the provision of a new bridge in lieu of one which had seen many years of service, a part of the cost should be borne by them, and the balance should be met by charges upon the Imperial and local exchequers as may be decided. As the nation and the local community would benefit by the unrestricted use of the highway, such a division of cost would be amply justified.

I feel that no apology is needed for annexing these few remarks upon bridges to a lecture upon Road Development to a military engineering audience. Responsible as you are or will be for national defence, it will readily occur to you how very important it is that these defects in the otherwise excellent lines of transport should be dealt with by the powers that be at an early date. These prohibited bridges are to be found over every canal and railway in the United Kingdom, but perhaps, for the mileage of roads traversed, the trouble in the South of England is most pronounced. The money value of good roads to the nation is enormous. What is inefficient is never in truth cheap. And in no instance is this fundamental maxim more certainly true than in the case of roads over which a large traffic passes. Make haulage easy and swift, and at once the conveyance of material of all descriptions being cheaper, the price in the competition market for sales will necessarily fall. Locomotion will always be cheaper on good roads than bad, and this directly constitutes an addition to the wealth-producing power of the country, diminishing the cost of wear and tear of animals and carriages, and the expense of the journey to travellers, by facilitating and accelerating the rapid transaction of business by intercommunication between one place and another. The improvement to the roads which has so satisfactorily commenced, must be diligently pursued. That increased volume of traffic and

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speed of same must mean increased expense, no thinking person will contest. The difficulty, particularly since 1903, has been that the incidence of charge has not been equitably distributed. Now Parliament has to some extent remedied this by the increased duty upon motor cars, and by the imposition of the Petrol Tax, the money to be derived thereby to be expended upon the improvement of the roads. This appears to me to be eminently sound finance and equitable both to the motorist and to the road authority.

As to procedure, I venture to predict that for the next few years the nearest attainment to the ideal in road maintenance will be found in :—

1. Building up the roads as strongly as possible, reducing camber to an uniform cross fall of 1 in 30.
2. Coating the surface with the best obtainable hard material broken to a gauge of not less than 2″ and not larger than 2½″ well rolled and consolidated, only clean hard gravel and chippings being used as a binding agent.
3. When the whole has dried out, thoroughly sweep the surface and apply a dressing of heated tar compound, covering same lightly with clean sharp sand or fine granite chippings.

A surface so constructed is the cheapest form of improved road to provide, is almost dustless, gives good travelling for traction engines and heavy motors, and is the least slippery for horses. I am not sure that any other method, at no matter what expense, could be made quite as satisfactory for all users of the roads.

The new Road Board which has been brought into existence to disburse the money derived from motor and petrol taxation, is in the position of a trustee of these funds, and the Board will doubtless hold the scales evenly, so that the owners of vehicles will find that the payment of these demands is in fact an investment in a gilt-edged security, because the comfort to be derived and the saving in wear and tear will be out of all proportion to the sum demanded by the Inland Revenue authorities.

If in the course of my remarks I have too frequently referred to the county of Kent, I am sure that I shall be forgiven. By virtue of the position I have the honour to hold, it follows that my experiments and knowledge of results must, for the most part, have been obtained within its confines, and also because we have endeavoured to keep ourselves in the forefront, by trying, with more or less success, the various processes which have never lacked advocates. The record of my mistakes and failures, as well as that of whatever little success I have achieved, is always at the disposal of the S.M.E., and I can promise, at all events, to show what to avoid, if not what to emulate.

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THE FYERS FAMILY.

(*Concluded*).

By Col. Robt. H. Vetch, c.b., late R.E.

The memoir of Major-General Sir William Reid, which was finished last month, was begun, it will be remembered, in connection with the history of the Fyers family, of which he was a member on the spindle side. Owing to the importance of the subject it was printed under a separate heading. The concluding portion of the original paper, "The Fyers Family," was therefore postponed. Two other members of this family on the female side—Major-General E. R. James, R.E., and Colonel H. F. Turner, C.B., R.E.—have also been commemorated under their own names. It now remains for me to bring the account of the Fyers family to a close.

In the *Royal Engineers Journal* for December, 1909, a short notice was promised of Colonel Amelius Beauclerk Fyers, R.E., Surveyor-General of Ceylon, youngest child of Major-General Thomas Fyers, R.E. I have found much less information available than I expected and it must therefore be very brief. In the same number of this *Journal* I expressed a hope that I might be able to furnish genealogical tables to elucidate the text and make the relationship in this large family a little more intelligible.

These tables have been prepared, but it is not considered advisable to incur the expense of reproducing them.

I need hardly point out that the statements, or lists, of descendants given in December, 1909, were prepared on the best information then obtainable, but the year that has passed has brought me a large correspondence, and "Corrections and Additions" have been supplied to me which will be found under that heading at the end of this paper.

And here, perhaps, I may be allowed to make my acknowledgments to all those members of the family who have assisted me in getting a difficult matter fairly right, and have evinced so much good will and desire to help. The genealogy of so large a family is no doubt an intricate and troublesome task, but I shall be amply repaid for my labour if it prove sufficiently accurate to be useful, and if it lead others to similar studies of their own family history.

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With some experience of biographical writing, in which accuracy of facts and dates are a *sine quâ non*, I am persuaded that the pursuit of hunting up these facts and dates, verifying references, comparing one account with another, discriminating between them, and deciding on the most probable, is a very beneficial one to the pursuer, and even has fascinations of its own.

A tolerably near approach to accuracy in small details is all that can generally be obtained. Absolute accuracy in such matters is a will-o'-the-wisp. I remember a curious case in point which happened to myself long ago. I was hung up for want of knowing the exact date of the death of a man whose biography I was writing. It was a trivial matter, for the month would have been sufficient, but I thought I might as well have the day if it could be got. I wrote to the family, I searched the files of the *Times* newspaper, I looked up books of reference. A member of the family sent me the day of the month, the *Times* notice gave a different one, and a copy which I obtained of the inscription on the tomb gave a different *year*. I felt rather sick to find after all my trouble there was so much disagreement; but it was clear that the inscription on the tomb was an error, and I had to choose between the day given by the family and that of the obituary notice in the *Times*. I think, if I remember right, I elected to trust the *Times*, as the notice would probably have been carefully prepared at the time by a member of the family.

COLONEL AMELIUS BEAUCLERK FYERS, R.E.

The youngest child, in a family of eleven children, of Major-General Thomas Fyers, R.E., and grandson of Lieut.-General William Fyers, Colonel Commandant, R.E., Amelius Beauclerk Fyers was born in Jersey, where his father was Commanding Royal Engineer, on the 12th July, 1829.

His mother, it will be remembered, was Louisa Clifton, daughter of the Rector of Alverstoke in Hampshire, and a lineal descendant of Sir Gervase Clifton, *tempus* Edward I.

More than that, she was a lineal descendant of the Lord Clifford of Skipton who married Elizabeth, great-granddaughter of Lionel, Duke of Clarence, son of Edward III. Mr. Albert Brownrigg Fyers, a grandson of Colonel A. B. Fyers, Surveyor-General of Ceylon, has kindly sent me two genealogical sheets, one showing the Clifton and the other the Clifford and Royal line, in which these descents are shown. They are appended to this paper.

The year following the birth of Amelius B. Fyers, his father was ordered to Mauritius as Commanding Royal Engineer, and he took his family there. Major-General Thomas Fyers did not return to England

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until 1845, when Amelius was preparing for the Royal Military Academy at Woolwich; he died the following year, after Amelius had become a Gentleman Cadet. Young Fyers got his commission as Second Lieutenant in the Royal Engineers on the 15th December, 1847. After going through the usual course of instruction at Chatham, he was appointed Field Instructor and held the billet from January to June, 1849. He was then ordered to Mauritius, which suited him very well, as his mother and several members of the family were living there. He had not been long there when he became engaged to be married to Miss Anne Eliza Brownrigg, daughter of Capt. William Meadows Brownrigg of the 13th Light Infantry, and great-niece of General Sir Robert Brownrigg, 1st Baronet, K.C.B., and Colonel of the 9th Foot. The young lady was on a visit from Australia, where her father had settled, to her uncle, Capt. Charles Cornwallis Brownrigg, and his wife, Rose Matilda Fyers, who lived at Beau Bassin in Mauritius. The marriage took place on the 24th October, 1850, at the church of St. Thomas Plaine Wilhelms, where the knot was tied by the Rev. Langrishe Banks, Civil Chaplain, brother-in-law of the bridegroom by his marriage with Louisa, daughter of Major-General Thomas Fyers.

Amelius B. Fyers was promoted to be Lieutenant on the 20th December, 1851, and 2nd Captain on the 18th August, 1856. He remained at Mauritius until the autumn of 1858. In addition to his military duties he was Government Meteorological Observer in the island from the time of his arrival until his departure nine years later. Five of his children were born in Mauritius.

On arriving home he was sent to Chatham for a time to command a company, and then to the Curragh Camp in Ireland. In September, 1861, he was ordered to Malta where he remained for four years, receiving his promotion to 1st Captain on the 3rd April, 1862.

From Malta he went to Ceylon at the end of 1865. The following year he was appointed Surveyor-General of the Colony with an official seat on the Legislative Council. He was placed on the Seconded List of the Corps on the 13th February, 1866. He lost his first wife at Colombo on the 20th April, 1869. A few years later he married again. The rite was performed in the Cathedral at Colombo by the Lord Bishop of the diocese, on 31st December, 1872, and the bride was Adelaide Isabella Forbes Leith, youngest daughter of Colonel Forbes Leith, of Whitehaugh, Aberdeenshire. She died at Aberdeen two years later, after the birth of her only child, on the 22nd November, 1874.

On the 5th July, 1872, Fyers had been promoted to be Regimental Major, and on 18th October, 1873, to a Regimental Lieut.-Colonelcy. At the expiration of 10 years in Colonial employment on the Seconded

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List he was compelled by the regulations to elect either to return to military duty, or to be placed on the Permanent Reserve List and relinquish a military career. He chose the latter and was continued in his appointment as Surveyor-General of Ceylon. He was placed on the Permanent Reserve List on the 13th February, 1876, and promoted to be brevet colonel on the 18th February, 1878.

Fyers came to England on leave of absence from Ceylon for a year in April, 1881. On its expiration he was granted a second year's leave on account of the state of his health. Unfortunately his health did not improve and he died at Bath, only a few days before the expiration of the extended leave of absence, on the 5th April, 1883. He was buried at Bathwick Cemetery. His funeral was attended by Colonel Henry Fyers, R.A., Major Henry Fyers Turner, R.E., Major-General John Jervois, R.E., Dr. Fox, and other relatives and friends, besides the mourners of his own family.

The 17 years during which Colonel Fyers held the important position of Surveyor-General of Ceylon were busy years in the progress of the Colony. He was responsible for great improvements in the public works of the island, as he combined the office of Director of Public Works with that of Surveyor-General. He was General Manager of the Ceylon Railways and of the works of the Colombo breakwater, upon which he wrote a paper. He was a prominent Fellow of the Royal Geographical Society of London.

By his first wife, Anne Eliza Brownrigg, Colonel A. B. Fyers had issue :—

I. Mary Anne Louisa Fyers, born at Mauritius on the 23rd August, 1851. She married on her 18th birthday Harry Maule ffinch, of the Ceylon Civil Service, and has issue :—(1). Annie G. Maule ffinch. (2). George B. Maule ffinch. (3). Knightley H. Maule ffinch. (4). Medora K. Maule ffinch. (5). Harry Maule ffinch. (6). Mary Stephanie Maule ffinch. (7). Beryl L. Maule ffinch.

II. William Amelius Beauclerk Fyers, born at Mauritius on the 18th October, 1852 ; died at Trincomalee, Ceylon, 16th July, 1886. He entered the Ceylon Civil Service, and married first Eliza Bogue, only child of John Bogue. She died in March, 1882. He married secondly Cissy Neville. By his first wife he had issue :—(1). Florence Juanita Fyers. She married J. E. Bunce. (2). Mabel Irene Fyers. (3). Harry Amelius Beauclerk Fyers, born on the 22nd August, 1881, married at Jeppestown, South Africa, Jessie Maude Lillegett.

By his second wife he left a son :—(4). Amelius Beauclerk Fyers, born on the 31st December, 1885.

III. Charles Cornwallis Meadows Fyers, born at Mauritius on the 13th February, 1854, was in the Surveyor-General's Department of Ceylon. He married on the 5th June, 1875, Marian Mitchell and had issue three sons, and a daughter who died young. (1). Charles

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William Alexander Clifford Fyers, born 12th April, 1876. (2). Albert Edward Brownrigg Fyers, born 26th August, 1878. (3). Wallis Walter Fyers, born 3rd April, 1880.

Mr. C. C. M. Fyers retired from the post of Superintendent of Surveys on the 24th December, 1907, after 35 years of strenuous work in the Colony. Perhaps the most important service he rendered to the Colony was the initiation and persistent advocacy of Kalakuda as a port of call. For 15 years steamers have been in and out of this port in perfect security. He also earned the gratitude of the Passara planters for his survey work in the Uva and eastern provinces. He was for many years a member of the Irrigation Board.

IV. Renée Sabine Fyers, born at Mauritius on the 9th July, 1855; married H. C. P. Bell, Ceylon Civil Service, son of Lieut.-General H. W. B. Bell, Royal (Bombay) Engineers, and had issue :—(1). Eva Laura Bell. (2). Renée Isabel Bell; married A. Prideaux. (3). Harry Amelius Bell; married Ethel Howard. (4). Cyril Francis Bell. (5). Zoë Iris Bell. (6). Malcolm Fyers Bell.

V. Laura Isabella Fyers, born at Mauritius on the 6th September, 1857; married Charles Morant Lushington, Ceylon Civil Service, and has issue :—(1). Lilian Renée Lushington; married Capt. Sydney Smith, R.A. (2). Charles Fyers Lushington. (3). Adelaide May Lushington; married Major Anson Firth, Indian Army, who died in 1906, leaving a son and a daughter. (4). Arthur Beauclerk Lushington. (5). Godfrey Law Lushington (deceased). (6). Alexander Nelson Lushington. (7). Ida Frances Lushington.

VI. Henry Francis Clifton Fyers, born at the Curragh, Ireland, on the 13th March, 1859, was in the Ceylon Forest Department. He married, in London, Alice Mary King, daughter of James King, of Belsize Park Gardens and late of the Cape.

VII. Frances Henrietta Fyers, born at the Curragh, Ireland, on the 14th October, 1860; died at Tynemouth, Northumberland, on the 11th October, 1890. She married on the 9th December, 1884, Percival George Parkinson, Captain, 1st Royal Dublin Fusiliers. He was transferred to the Ordnance Store Department and retired from the Service as a Lieut.-Colonel on the 31st December, 1907. He had issue three daughters and a son, viz. :—(1). Gladys Frances Parkinson, born 10th January, 1886. (2). Irene May Parkinson, born 14th May, 1887. (3). Esmé Mildred Parkinson, born 5th September, 1888. (4). Claude Beauclerk Fyers Parkinson, born 8th September, 1890.

VIII. Robert Montagu Fyers, born at Malta 29th August, 1863; died 19th June, 1864.

IX. Adelaide Hay Fyers, born at Malta on the 5th February, 1865; married Christopher Hodgson and has issue :—(1). Harold

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Hodgson. (2). Gladys Hodgson. (3). Dorothy Hodgson. (4). Lionel Hodgson.

X. Kate Minnie Fyers, born at Colombo, Ceylon, on the 6th August, 1867; married F. M. Simpson, Ceylon Civil Service, son of Admiral Simpson, and has issue :—(1). Dorothy Adelaide Simpson. (2). Katharine Renée Simpson. (3). Frances Courtland Simpson.

By his second wife, Adelaide Isabella Forbes, Colonel Amelius Beauclerk Fyers had a daughter, viz. :—

XI. Amelia Adelaide Wilhelmina Helen Fyers, born in Aberdeen on the 18th November, 1874.

Reference has been made in the earlier part of these papers to the origin of the Fyers family. It was suggested that it might have sprung from a son of the third Lord Lovat, early in the 16th century, and that its home was in Stratherrick, the glen in which is situated the waterfall of Foyers. And here it may be noted that the poet, Robert Burns, spelt the name "Fyers" in his "Lines written with a pencil, standing by the falls of Fyers, near Loch Ness."

I found that Major Evan Fyers was in possession of a "Note of Search in the Parish Registers of Berwick-on-Tweed, 1572—1770, made in January, 1903," which shows that the forbears of Thomas Fyers, Overseer of the King's Works in Scotland, were recorded for four generations back. The earliest date of the mention of the name, the spelling of which varied, as in the case of most names in those days, was the marriage on the 23rd July, 1660, of John Fyre (*sic*) to Isabell Gibson. There is no mention in the registers at Berwick of the name earlier and it is not unreasonable to suppose that John Fyre may have wandered down south from Stratherrick in search of work, as is the way with many of my fellow-countrymen, and having found a wife in the border town, and probably employment on the fortifications, settled there.

The next entry from the registers is :—

"1621. April 22nd. Peter the sone of John Fire" (*sic*) baptized. Then comes Peter's marriages; first to Isabell Mireless, on the 9th February, 1645–6, followed later on by the baptisms of two children; second, on the 22nd August, 1654, to Elizabeth Edington daughter of Alexander Edington, late of Kelsae, in the Sheriffdom of the Morse in Scotland. This second marriage brought an addition of four sons and four daughters whose baptisms are all registered.

The eldest of these sons by the second wife, Peter Fyers, was baptized on the 14th August, 1655. He married, on the 10th June 1679, Margaret Roger, and had issue two sons and three daughters. The elder of these two sons was William Fyers, baptized on the 20th February, 1679, who became a Burgess of Berwick-on-Tweed in 1703. He married, but apparently away from his native town, as his marriage does not appear in the Berwick Register. The name

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of the wife is not known, but he had five sons and a daughter, the dates of whose baptisms are all given. The eldest son was Thomas Fyers, Overseer of the King's Works in Scotland.

The second son of Peter Fyers is entered thus :—

Baptism—" 1681. September 4th. John, son of Peter and Margaret . . . baptized (page torn)."

Marriage—" 1706. May 14th. John Fyars (Cooper), and Rebeccah Parke."

They had a family of one son and four daughters, one daughter, Jane Fyers, marrying on the 16th September, 1734, John Mills.

We have therefore :—

I. John Fyre, married, in 1620, Isabell Gibson, and had a son :—

II. Peter Fire, baptized in 1621, buried in 1696, who married as his second wife Elizabeth Edington in 1654 and had a son :—

III. Peter Fyers, baptized in 1655, who married, in 1679, Margaret Roger. Their eldest son was

IV. William Fyers, baptized 1679; made a Burgess in 1703; married . . . by whom he had a family, the eldest being

V. Thomas Fyers, baptized 27th December, 1714; made a Burgess of Berwick-on-Tweed in 1735. Overseer of the King's Works in Scotland. He married, in 1750, Elizabeth Falconer (1731—1815) and died in Edinburgh on the 17th June, 1784. Their children were :—

(1). Elizabeth Fyers, born at Inverness on the 13th October, 1751 (O.S.); married George Peter, of Chapel, near Moffat, and had issue a son and two daughters, all unmarried. The son, George, was in the 59th Foot and became a Colonel in the Army.

(2). William Fyers (1753—1829), Lieut.-General, Colonel Commandant, Royal Engineers; married at New York in 1781 Anne Wanton (1754—1808). Their family has been fully described.

(3). Anne Fyers, born at Edinburgh on 16th April, 1755; married, as his second wife, John Thompson, Esq., of Leith, whose son by his first wife became Sir John Thompson, of the Cape of Good Hope.

(4). Alexandrina Fyers, born in Edinburgh in 1757; married Rev. James Reid, of Kinglassie, Fife. Their family has been described.

(5). John Fyers, born in Edinburgh 20th August, 1759, and died there on 17th June, 1775.

(6). Mary Fyers, born in Edinburgh, 6th September, 1761; married, as his second wife, on 28th December, 1798, the Rev. Donald Mackenzie, minister of Fodderty, Ross-shire, who by his first wife had issue Major Colin Mackenzie, R.E., who died in 1870.

(7). Margaret Fyers, born in Edinburgh on 17th July, 1763; married William Kerr, Russian merchant, and had issue a son, James Kerr, who married and had a daughter, Margaret.

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(8). Thomas Fyers, born in Edinburgh on 1st November, 1767, Treasurer of Malta; died unmarried at Malta on the 12th October, 1815.

(9). Peter Fyers (1769—1846), Major-General and Colonel Commandant, Royal Artillery, born in Edinburgh on 21st December, 1769; married, in 1812, Frances Bolland (1791—1867). Their family has been fully described.

We have shown that from Lieut.-General William Fyers alone no less than 48 descendants had entered the Army and Navy. But if we include all the descendants of Thomas Fyers, Overseer of the King's Works in Scotland, and the officers of the two services whom the daughters of the house married the total number would be 78.

CORRECTIONS AND ADDITIONS.

CORRECTIONS AND ADDITIONS TO THE LISTS (SEE DECEMBER NUMBER, 1909) OF THE GRANDCHILDREN AND FURTHER DESCENDANTS OF LIEUT.-GENERAL WILLIAM FYERS, COLONEL COMMANDANT, R.E.

Lieut.-General William Fyers had 10 children by his wife Anne Wanton. Particulars were given of the families of four of them, viz., of Thomas Fyers, Sarah Mann, Charlotte Anne Young and Elizabeth Lydia Gardner.

CHILDREN AND DESCENDANTS OF MAJOR-GENERAL THOMAS FYERS, R.E., AND HIS WIFE, LOUISA CLIFTON:

I. William Fyers . . . leaving issue:— . . . (3) a daughter Louisa who married a Greek gentleman named Marchetta.

* * * * *

III. Louisa Fyers . . . married the Rev. Langrishe Banks, Civil Chaplain. He died of cholera in Mauritius on the 21st June, 1854. His wife died in Dublin on the 14th February, 1893, aged 81 years. She was buried in Mount Jerome Cemetery beside her eldest son. She had issue a daughter who died in infancy and two sons, viz.:—

(1). William Thomas Banks, so named after his maternal grandfather and great-grandfather, Major-General Thomas Fyers and Lieut.-General William Fyers, was born in Mauritius on 2nd March, 1835. He took his B.A. degree at Trinity College, Dublin, and was ordained in Lichfield Cathedral in 1860. He was appointed Civil Chaplain in Mauritius in 1862 and returned to the island to hold the same position as his father had held. He there married on the 16th June,

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1863, Helen Rebecca Paterson, widow of Lieut. John Brand Paterson, R.E.,* and daughter of Charles Cocks, Esq., B.L., a good linguist and translator of Michelet's *History of the French Revolution* for Bohn's Standard Library. The Rev. W. T. Banks remained in Mauritius until 1867, when illness compelled him to return to England. He died in Dublin after an operation on the 20th January, 1868, at the age of 32 years and was buried in Mount Jerome Cemetery. He had a family of three daughters, one of them died in infancy at Mauritius. The others are: (*a*). Eileen Louisa Banks, born at Mauritius on 23rd February, 1864; she married in Dublin on 10th January, 1894, the Rev. Charles Saunders Graham and has no issue. (*b*). Edith Gertrude Banks, born in Mauritius on the 30th October, 1866; unmarried.

(2). Langrishe Fyers Banks, born at Mauritius on the 26th September, 1836; educated at the Royal College there and appointed on the 1st July, 1854, to the Civil Service of the Colony. He went to Dublin on sick leave in 1858 and while there obtained the appointment of Assistant to the Secretary of the Royal Hospital, Kilmainham. He was promoted Secretary on 1st October, 1879, and held this position until 1st October, 1902, when he retired on a pension. He married at Bath on the 6th July, 1863, his cousin, Anne Sabine Wainwright [*q.v.*], by whom he has had issue: (*a*). Rosa Louisa Banks, born 17th August, 1864; died unmarried 23rd July, 1902. (*b*). Adeline Sabine Banks, born 27th April, 1866; died 10th January, 1868. (*c*). Anita Marion Banks, born 19th December, 1868; died 18th February, 1894. (*d*). Langrishe Fyers Banks, born 2nd May, 1871. (*e*). Ida May Banks, born 11th May, 1873. (*f*). Gerald Clifton

* Lieut. J. B. Paterson received his first commission in the Royal Engineers on the 7th April, 1856. He belonged to a batch which never passed through the Royal Military Academy at Woolwich but was admitted to the Arsenal Class of the cadets direct. The head of the batch, Robert Thaine, like Paterson, died at an early age at Hong Kong, after seeing service in the China War of 1857—1858. One member only of the batch survives, viz., Colonel D. C. Walker. Paterson served in the Indian Mutiny, was mentioned in despatches and received the medal with clasp. He was sent at the close of the war to Mauritius in 1859. He there married on the 10th October, 1861, Miss Helen Rebecca Cocks, but he died, on the 20th of the following month, from the effects of a sunstroke. There was no issue of this marriage. His widow, after becoming the widow of the Rev. W. T. Banks, married, as her third husband, Christopher John George Guy-Carleton at Kingstown, co. Dublin, on the 3rd May, 1877. He died at Dublin on the 1st May, 1897, leaving three daughters: (*a*). Helen Guy-Carleton, born at Kingstown, co. Dublin, on 10th March, 1878; married on the 4th June, 1896, the Rev. A. G. Pentreath, D.D., C.F., and has one daughter and two sons. (*b*). Ethel Guy-Carleton, born at Dublin on the 16th November, 1884; unmarried. (*c*). Olive Beatrice Guy-Carleton, born at Dublin on the 15th December, 1886; unmarried.

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Banks, born 20th March, 1876. (*g*). Ernest Drake Banks, born 21st January, 1878; married Louisa Porter, daughter of Dr. Porter, of Bournemouth.

IV. Rose Matilda . . . was married . . . to Capt. Charles Cornwallis Brownrigg, of the 9th Foot, 3rd son of General Thomas Brownrigg and nephew of General Sir Robert Brownrigg, 1st Bart., K.C.B., Colonel of the 9th Foot. Capt. C. C. Brownrigg was born in 1800, and died without issue at the island of Bourbon whither he had gone for his health in 1872.

° ° ° ° °

VI. Thomas Edward Fyers . . .

(3). The daughter Alice Louisa . . . married in 1900 Frank D. Thomsett . . .

VII. Renée Theresa . . .

(1). Henry Fyers Turner . . . (*b*). Henry Hamilton Fyers Turner . . . He married Effie Campbell Ross, daughter of Colonel George Campbell Ross . . .

(3). Alfred Heyland Parratt Turner . . . He married Maria Anne Hill. . . . (*a*). Eustine Turner; married Lieut. C. Goolden, R.N. (*b*). Horace Gough Turner. . . .

(5). Archer Lhoyd Marischal Turner. . . .

(*a*). Archibald Frank St. Aubyn Turner . . .

VIII. Charlotte Sabine Fyers . . . married . . . George Drake Wainwright . . .

(6). Edward Arthur Clifton Wainwright . . .

IX. Amelius Beauclerk Fyers. (*Corrections where necessary have been made in the notice of Colonel A. B. Fyers in this paper*).

CHILDREN AND DESCENDANTS OF SARAH FYERS, WIFE OF MAJOR-GENERAL CORNELIUS MANN, R.E.

(*Very little information has been received from the Mann Family and only one correction, which refers to the only daughter of Major-General J. R. Mann, C.M.G., R.E.*).

XI. James Robert Mann . . . Major-General . . .

(4). Georgina Louisa Mann, born in Mauritius in 1856; married on the 24th January, 1880, J. W. B. Parkin, son of an officer of Royal Artillery, who retired early, and grandson of an Inspector-General in the Medical Department of the Royal Navy, who served all through the war with France at the end of the 18th and beginning of the 19th century. He is now Brevet Colonel and District Barrack Officer at Aldershot. He was formerly in the Army Service Corps. There have been four children of the marriage, of whom two sons survive, viz. :—(*a*). William Allan Brooke Parkin, born on the 19th February, 1881. He served as a Lieutenant, Royal Artillery,

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throughout the Boer War, receiving the 2 medals with 5 clasps. He left the Army to enter Holy Orders. (*b*). Herbert Denis Parkin, born on the 31st December, 1886, is a Lieutenant in the Northamptonshire Regiment.

Children and Descendants of Charlotte Anne Fyers, Wife of Vice-Admiral James Young, R.N.

o o o o o

III. Henry Young . . . Lieut.-Colonel, 24th Foot. . . . (*b*). Alice Stavely Young, born in 1844; married, in 1867, George Gordon, Esq., C.E., and had issue: (*a*). Alice Elizabeth Gordon, who married E. B. Gould, son of Nutcombe Gould, H.M. Consul, Alexandria, Egypt. . . .

VI. Charlotte Young . . . married Lieut. James F. Elton, of the 40th Foot. . . .

(1). Frederick Elton, born in 1836, was commissioned in the Royal Artillery in November, 1854. He married Olivia Power, daughter of Major Power. . . .

(2). Charlotte Elton; married Major-General R. G. Thorold, R.E. (*For issue see Thorold under Mann*).

Children and Descendants of Elizabeth Lydia Fyers, Wife of General the Hon. William Henry Gardner, Colonel Commandant, R.A.

II. Eliza Gardner . . . married the Rev. John Buckner, M.A., of Wyke House, Sussex, Vicar of Bapchild, Sittingbourne, Kent. . . .

(2). Georgina Buckner, who married —. Firminger, with issue: A son in the Church who married a Miss Carey, and two unmarried daughters.

(3). Mary Eliza (Minnie) Buckner; married at Grahamstown in December, 1850, John Henry Sale, then Deputy-Assistant Commissary-General. He served in the Kaffir War and was mentioned in despatches by Major-General Somerset, commanding a column under Lieut.-General Sir Harry Smith. He received the medal. He also served in the Crimea and received the medal with clasp "Sebastopol" and the Turkish Medal. He died in January, 1869, leaving issue:—

(*a*). Mary Anne Eliza Sale, born at Fort Beaufort, South Africa, on the 31st January, 1853; she married Franklin Taylor at Rugby on the 3rd August, 1876. He died on the 29th March, 1909, leaving issue:—(α). Mary Alice Taylor, born 23rd August, 1878; married

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Charles O. Law, and has a son, Denys Law. (*β*). MAURICE GROVE TAYLOR, born on the 31st May, 1881, Captain, R.E.; married on the 4th January, 1906, Winifred Hilda Thacker, by whom he has a son, Kenyon Taylor. (*b*). Charles John Buckner Sale, born at Hobart, Tasmania, on the 15th November, 1857. (*c*). George Henry Travers Sale, born at Perth, Western Australia, on the 11th September, 1861. These two brothers (*b* and *c*) are settled in Washington Territory, United States of America. The elder, Charles, is married and has issue. The younger, George, is also married but has no issue.

(4). Augusta Buckner married William Whitehead Gascoyne, with issue.

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TABLE I.

CLIFTON OF CLIFTON.

Sir Alvere Clifton.
|
Sir Robert Clifton.
|
Sir Gervase Clifton.
|
Sir Gervase Clifton = Amflisia, *d.* of Sir Wm. Sampson, Lord of Eperston, in 25th of Edward I.
d. 17th Edward II. |
|
Gervase Clifton = Alicia, *d.* of Robert de Rabacy.
|
Sir Robert Clifton = Emma, *d.* of Sir Robert Molton, Kt.
d. 1st Edward III. |
|
Sir Gervase Clifton = Margaret, *d.* of Sir Robert Pierrepoint.
|
Sir Robert Clifton = Agnes, *d.* of . . . de Grey.
|
Sir John Clifton = (2) Catherine, *d.* of Sir John Cressy.
|
Sir Gervase Clifton = Isabell, *d.* of Sir Robert Francis, Kt.
|
Sir Robert Clifton = Alice, *d.* of John Booth of Barton, Lancs.
|
Sir Gervase Clifton = Alice, *d.* of Thomas Nevell of Roleston.
|
Sir Gervase Clifton = Agnes, *d.* of Sir Walter Griffiths.
|
Robert Clifton = Anne, *d.* of Henry, 10th Lord Clifford.

*(For continuation see * in Table II.).*

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TABLE II.

Lionel, D. of Clarence (son of Edward III.) = Elizabeth de Burgh.

Philippa = Edmund Mortimer, 3rd Earl of March.

Elizabeth = Sir Henry Percy, K.G. ("Hotspur").

Elizabeth = John, 7th Lord Clifford of Skipton.

Thomas, 8th Lord Clifford = Johanna, *d.* of Thomas, Lord Dacre of Gillesland.

John, 9th Lord (the Butcher) = Margaret, *d.* and *h.* of Henry Bromflete, Lord de Vesci.

Henry, 10th Lord (Shepherd Lord) = Anne, *d.* of John St. John, Lord of Bletnesho.

* Anne = Robert Clifton of Clifton.

Sir Gervase Clifton = (2) Winifred *d.* and *h.* of William Thwaites of Mallowtree, Essex.

George Clifton = Winifred, *d.* of Sir Anthony Thorold of Marston, Lincs.

Sir Gervase Clifton, 1st Bart. = (6) Jane, *d.* of Anthony Eyre.

Robert Clifton = Sarah Parkhurst.

Robert Clifton of Blyth = Frances, *d.* of Christopher Packe.

James Clifton = Renée Guichard.

Rev. Francis Clifton = Rebekah Katherine, *d.* of Rev. J. M. Bingham.

Louisa Clifton = Major-General Thomas Fyers, R.E.

Colonel Amelius Beauclerk Fyers = Anne Brownrigg.

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TRANSCRIPT.

THE ARMY FIELD ENGINEER SCHOOL OF THE U.S. ARMY.

In the February number of the *R.E. Journal* details were given of the Engineer School at Washington. In the U.S. Army Order No. 69 of April 20th, 1910, details are given of the Army Field Engineer School and these are now added, as they are likely to prove of interest.

The Army Field Engineer School.

37. This school will be known as The Army Field Engineer School. Its object is the preparation of officers of the Corps of Engineers and of engineer officers of the organized militia for the better performance of their military duties.

38. The commandant and the secretary of The Army School of the Line will be the commandant and the secretary, respectively, of The Army Field Engineer School. The assistant commandant will be an officer of the Corps of Engineers with grade not lower than that of major.

Student Officers.

39. Selections of student officers will be made as follows :—

(*a*). The Chief of Engineers will submit to The Adjutant General of the Army, not later than January 1st of each year, the names of not less than 2 nor more than 10 officers of the Corps of Engineers for instruction in the school.

(*b*). There may also be detailed such engineer officers of the organized militia as may apply for entrance, subject to the provisions of paragraphs 5 to 17, inclusive, excepting paragraph 9 of this order.

The foregoing details will be announced in orders from the War Department.

Examination of Militia Officers for Admission.

40. The following will be substituted for the examination in military subjects as set forth in paragraph 9.

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(*a*). Administration. (Consult especially the following paragraphs, Army Regulations, 1908:—6, 9, 13, 14, 15, 16, 18, 57, 76, 77, 80, 83, 133, 134, 137, 186, 189, 190, 194, 195, 201, 212, 223, 224, 229, 449, 451, 452, 743, 765, 784, and 1510 to 1527, inclusive).

(*b*). Manual of Guard Duty.

(*c*). Manual for Courts-Martial.

(*d*). Field Service Regulations (Articles II., III., IV., and V.).

(*e*). Manual of Field Engineering, Beach (Chapters I.—X., inclusive).

(*f*). Topographical Surveying and Sketching, Rees (Chapters I., II., III., and XV., omitting analytical solutions).

In lieu of examinations in any of the foregoing subjects certificates of proficiency from garrison schools in such subjects will be accepted.

COURSE OF STUDY.

41. The course of study will be embraced in three departments, as follows:—

I.—The Department of Engineering.
II.—The Department of Military Art.
III.—The Department of Languages.

I.—ENGINEERING.

The study of this subject will be divided into two parts, theoretical and practical. Theoretical instruction will be by lectures, conferences upon assigned lessons, and written examinations. Practical instruction will be by problems and terrain exercises.

The course will comprise the following subjects and fields of inquiry:—

(*a*). Military map making:

- Surveying.
- Sketching.
- Map projection.
- Map reproduction.
- Photography.

(*b*). Organization, duties, and equipment of engineer troops.

(*c*). Field fortification:

- Hasty intrenchment.
- Deliberate fortifications.
- Sieges and siege methods.
- Demolitions.
- Mining.

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(*d*). Lines of communication:

Military roads.
Military railroads.
Military bridges.
Animal transportation.
Mechanical transportation.

(*e*). Castrametation:

Water supply.
Drainage.
Shelters.

II.—Military Art.

The study of this subject will be in all respects identical with the study of the same subject in The Army School of the Line, and will be conducted under the direction of the assistant commandant and instructors of that school. Student officers of The Army Field Engineer School will be graded in the Military Art course in the same manner as student officers of The Army School of the Line.

III.—Languages.

The course in languages will be elective, and will comprise instruction in French or German, as preferred by the student officer: Provided, That no student officer will be permitted to elect either of these languages unless he has a good conversational knowledge of Spanish. If not, he will take the same course in that language as is prescribed for The Army School of the Line. The course in each language will comprise instruction in reading, writing, and speaking, with a special view to acquiring a conversational knowledge of the language. Instruction will be given by conferences, lectures, and conversational practice.

Thesis.

42. Each student officer will prepare a thesis on some professional subject approved by the academic board and submit the same in the required form prior to June 15th of each year.

Co-operation.

43. The student officers of The Army Field Engineer School and the engineer troops on duty at Fort Leavenworth will be used to co-operate as far as possible with The Army School of the Line, The Army Signal School, and The Army Staff College in terrain exercises, manœuvres, and staff or tactical rides, to the end that student officers of all these institutions may obtain the maximum benefit from the exercises prescribed.

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EXAMINATIONS.

44. Any student officer of this school whose progress in any of his studies is not entirely satisfactory to the academic board will be examined therein under the provisions of the rules governing examinations and proficiency prescribed in paragraphs 19 to 24, inclusive.

RECORD, ARRANGEMENT AND PUBLICATION.

45. For record at the school and at the War Department the members of the class, upon the satisfactory completion of the course, will be designated as graduates. The term "graduate" will signify that the student officer has attained a proficiency in all of his studies satisfactory in every respect to the academic board or has obtained at least 75 per cent. in each of those subjects in which he has been examined or re-examined.

In all published lists the names of the graduates will be arranged in alphabetical order.

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REVIEW.

ALGO DE POLÉTICA NAVAL.

THE author of this pamphlet, Colonel Don José Viciana of the Spanish Engineers, has been so good as to send a copy of his work to the R.E. Institute. It consists of four chapters, the first containing a description of the various types of vessel to be found in a modern fleet, the second dealing with coast defence, the third proposing a new type of floating battery or concrete monitor, and the fourth devoted to a short consideration of Spanish naval policy.

The chief interest of the work lies in Chapter III., in which the author makes the novel proposal to construct vessels, protected by armoured concrete and provided with a powerful armament for use in coast defence. He suggests vessels of 37,000 tons displacement, armed with four 9·2″ and six 4·7″ guns mounted in concrete cupolas 6′ 6″ thick, placed on an armoured concrete deck 12″ in thickness. The battery will consist of two essential parts, a deck of ordinary concrete 5′ 6″ thick, inclined at an angle of 11° 20′ with the horizontal, resting on an under deck of armoured concrete 12″ thick, which is supported by pillars of armoured concrete, resting on the flat bottom on the vessel. The hull of armoured concrete is divided up into a number of compartments and the author calculates that it would have ample strength to resist the shock of a torpedo exploded against it. The dimensions of the battery are approximately 260′ long, 180′ wide, and 36′ in depth. It would be driven at a speed of 4 knots by two 500-H.P. internal combustion engines.

The author estimates that the cost of the battery would be about £50,000 for the hull and about an equal amount for the armament and engines, or a total of £100,000.

In Chapter IV. the author considers that the two battleships of 15,700 tons, the *Alfonso XIII.* and *España*, which are being built at Ferrol for the Spanish Navy, will be of very little use to it, and that it would have been far preferable to have spent the money which they will cost on small cruisers of 3,500 tons, armed with from 12 to 15 4″ or 4·7″ Q.F. guns with which to attack an enemy's commerce. He approves the construction of 3 destroyers and 24 torpedo boats which are to be laid down at Cartagena, and considers that submarines should also be provided.

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NOTICES OF MAGAZINES.

REVUE MILITAIRE DES ARMÉES ÉTRANGÈRES.

May, 1910.

THE GERMAN IMPERIAL MANŒUVRES OF 1909.—A long account of the operations is given, followed by various comments, of which a *résumé* follows:—

(1). As far as the infantry is concerned, the most noticeable point is the length of the marches they made:—the 39th Division did 95 kilometres in 3 consecutive days; the 14th Corps 135 in 4 days; and the 1st Bavarian Corps 30 to 45 in 1 day. These marches were undertaken in very hilly country, on bad roads, and in detestable weather; it is however only fair to note that the troops suffered severely from them, and that the percentage of stragglers was greater than usual.

(2). *Cavalry.*—The country was very favourable to the action of cavalry, and much use was made of dismounted action. The cavalry of both sides was however far too prone to remain stuck to the flank of the force it was attached to. The cavalry is armed with sword, rifle and bayonet.

(3). *Artillery.*—Much use was made of the heavy artillery, and in spite of the bad state of the ground it was always possible to bring the heavy batteries into action. All the artillery seemed thoroughly imbued with the spirit of the regulations and paid the greatest attention to supporting its infantry. The batteries often came into action in open positions without making any attempt at concealment or to entrench.

(4). No cyclists took part in the manœuvres.

(5). *Machine Guns.*—To each cavalry division was attached a machine gun detachment of 6 guns and 3 ammunition wagons. The strength of the detachments was 87 men and 54 horses. Machine gun companies of 6 guns each were also employed, one with each infantry regiment. Sixteen of these detachments, or 96 guns in all, were employed on the manœuvres.

(6). *Dirigible Balloons.*—The airship "Gross 2" was employed; it was provided with a wireless telegraphy apparatus. A special hangar was erected for it. The experiment does not appear to have been a success, and the wireless apparatus did not come up to expectations.

(7). *Communications.*—On each side the headquarters were connected to the army corps, and in the case of the Blue side to the airship also, by means of wireless telegraphy. A detachment of telephonists was attached to each infantry division. The telegraphic and telephonic communications of the two armies were very satisfactory; 140 motor cyclists

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were also used. After many experiments, the Army Council has at last decided on the adoption of a 5-H.P. 2-cylinder motor cycle as the most useful pattern of vehicle of its class.

THE CHINESE ARMY IN 1910.—The Chinese Army now consists of:—(1). The new Regular Army (Lou-Kiun). (2). The Auxiliary Police Force (Siun-fang-toei). (3). The modern Police Force (Siun-K'ing-Kiun). (4). The contingents of the Mandchu Banners (Pa-K'i). (5). The remnants of the old army of the Green Banner (Lou Yng). (6). The rural Militia (Toan-lien). (7). The Mongolian and Tibetan contingents. (8). The river troops (Choei-che-ying, and Choei-che-Kiun-K'ing). All the above forces, except (3) which is under the Minister of the Interior, are directly under the General Staff and the War Minister. Great encouragement has been given to the army, with the idea of abolishing the old contempt of the civil mandarins for the military ones, new schools for the training of cadets have been opened, and examinations have been instituted to ensure that no one can obtain a commission without certain definite educational qualifications.

With reference to the various constituent parts of the army, the following are brief notes as to their respective strengths, efficiency, etc.:—

As regards (1):—Its strength is 152,565 men, of whom 120,000 are fully trained and could appear on a modern battlefield with a fair chance of success. It drills well in close order. The infantry knows how to make use of the ground, but shoots badly, whilst the cavalry is as yet insufficiently trained, rides badly, and is not yet thoroughly imbued with the cavalry spirit. Practice camps are as yet too rare in the field artillery, and although the engineers are comparatively well trained, the supply and transport corps requires organization, and the departmental corps are as yet non-existent. Finally although the progress since 1903 is extraordinary the discipline is rather lax and the operations of the younger generals savour still somewhat of the textbook.

As regards (2) these are but temporary troops, which will be abolished when the divisions of (1) are provided with their full complement reserves. They are employed to guard roads, railways, and for police duties generally.

(3) is efficient, but cannot be reckoned on as a serious military force, so occupied is it with its police duties.

As regards (4):—Of 5,000,000 of Manchus, 227,000 are obliged to serve as soldiers, of which 33 per cent. may be considered as efficient, and 67 per cent. as having undergone no military training at all.

(5) is absolutely useless and will be completely abolished within the next three years.

(6); of these the only militia of any military use is that of the Yunnan.

(7); the strength of this contingent is about 112,000 men, of whom only 11,000 to 12,000 can be considered as efficient, the remainder being armed with such obsolete weapons as bows and arrows, flintlocks, breechloaders, and similiar curiosities generally found in museums.

(8); these troops have hitherto been a collection of units entirely independent of one another, they are now however to be amalgamated

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and reorganized; the tendency of the Chinese Government at present with reference to them, is to spend too much money on the gunboats, whilst the men themselves are not trained or equipped sufficiently to get the full value out of the good *matériel* with which they are provided.

To sum up:—Since 1903 China had made progress, in as far as her army is concerned, but her officers and N.C.Os. are not as yet trained, her General Staff lacks experience, her artillery armament is not uniform, and her musketry instruction and remount depôts very poor. All these faults will disappear the day that more funds for the army are forthcoming.

MILITARY NEWS FROM DIVERS COUNTRIES.—*Germany.*—A large number of small motor cars, of 8 to 12-H.P. have been recently acquired by the experimental branch of the communication troops; they are to be used at present to train chauffeurs and it is not improbable that they will eventually replace motor cycles as the means of locomotion of despatch riders. The new regiment of Saxon Hussars, which is to be raised on the 1st October, 1910, will be clothed from the very beginning with the new grey field service uniform; on the other hand the Prussian cavalry regiment raised on the same date will retain the old uniform. The German remount department's reports for 1909 are very satisfactory, and show that the increase in the use of the automobile, and the increase in breeding of heavy draught horses has by no means injured the breeding of the remounts; but on the other hand, their price has gone up from £50 in 1906 to £53 10s. in 1909. The increased hardships of manœuvres during the last few years have told heavily on the cavalry horses, with the result that the inspector-general of the cavalry has taken the following steps:—

(1). The daily hay ration is increased.

(2). The hours of the cavalry on manœuvres are shortened.

(3). As far as possible the use of bivouacs by mounted troops is abolished.

Spain.—The strength of the army of occupation at Mellilla, has been reduced from 37,000 to 30,000 men.

Italy.—The new grey-green field service uniform is now obligatory for officers when on duty with troops so clad. They are however not to wear it at the theatre or off duty after 3 p.m.

A. H. SCOTT.

RIVISTA DI ARTIGLIERIA E GENIO.

September, 1910.

BRIDGES OF BOATS ANCHORED TO A CABLE.—Among the various kinds of military bridges which have not up to the present been of great practical use because they are not always of easy construction but which offer advantages under certain circumstances, are some which are worthy

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of examination because of their use to engineer troops. Bridges of boats anchored to a cable are a good instance. The excellent results obtained with bridges of this kind, in Switzerland, in various trials on the Aar would seem to point to their introduction in the programme of instruction in the construction of military bridges for that nation. A careful study of the statical calculations in connection with such bridges has been made by Lieut. Huguenen, and was published in the *Revue Militaire Suisse* of September, 1909.

Bridges of this kind present the following advantages: independence of the depth of the rivers, and variations in the level of the water, greater security from losses caused by floating bodies, possibility of construction during the night and without danger.

In order to calculate the principal elements of construction of such bridges, it is necessary to determine beforehand all the external forces which act on the restrained body, and long and numerous trials are indispensable. An absolutely rigorous calculation has considerable difficulties, but the problems may be simplified. The fundamental hypothesis presented in the study is that which relates to the nature of the curve assumed by the cable under the action of various forces. It is admitted that this curve has the form of a catenary, or it may approximately be that of a parabola. The bridges which have been constructed up to now have shown clearly that this simplification may be accepted without prejudice to the grade of exactness required for a work of this kind.

Determination of External Forces.—The author commences by describing the method employed for determining the tension produced by a boat, variously loaded, upon the restraining rope.

Three different methods of keeping the boats in their places were tried:—

1st. Normal anchorage with ordinary anchors.
2nd. Anchorage to the cable by means of a restraining rope of 20 m. in length.
3rd. Anchorage to the cable by means of a rope 7 m. in length.

The following results were obtained with a boat of 2030 k.g. displacement and a current of 3·5 m. per second.

Tension on the restraining rope: 116 k.g. with the 1st method of anchorage.

Tension on the restraining rope: 75 k.g. with the 2nd method of anchorage.

Tension on the restraining rope: 55 k.g. with the 3rd method of anchorage.

The anchorage to the cable with the above current velocity produced on the restraining rope a tension only about half of that of an immersed anchor.

The author gives very elaborate calculations, and drawings and sections for the calculation of the tensions on the cable for boats of different displacements and for different velocities of the stream.

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MISCELLANEA.—*France.—La France Militaire* of the 2nd September announces the invention of a new smokeless powder, by the photographer Guichard, which is more powerful than that now in use in the French Army. From comparative experiments made near Montciel, it appears that with the same amount of powder the bullet of the Lebel rifle penetrated 635 m.m. in a certain target when the regulation powder M was used, while with the new Guichard powder the penetration was 732 m.m. This new explosive is, further, absolutely free from smoke or smell; is very stable, and is not influenced by damp or heat (it does not decompose at a temperature of 70° Centigrade); it does not explode by shock or under pressure; it burns slowly, developing a progressive force, and does not leave a residue like that of the powder M. The inventor has requested the Minister of War to make trials by a competent commission of this new product.

Telephonic Material for the Infantry.—La France Militaire also states that telephonic material is now distributed to infantry troops, and that it is composed essentially of complete micro-telephonic stations, with material for the lines composed of steel wire. All the material is very simple. The instruments for the stations are packed in portable bags, which are carried by the telephonists either on their belts or in some other manner. A limited number of men, who have received the necessary instruction and who understand the repairing of the instruments and apparatus, are employed on this work. The extension of a telephonic line is very rapid, so that communication on the field of battle can be fully maintained by this means.

REVIEW OF BOOKS.—*Count Camillo Benso di Cavour.*—On the occasion of the centenary of the birth of Count Cavour, Colonel Turletti has published the present volume in which the life of this famous Italian statesman is depicted in the succinct and simple form that is suitable for a work dedicated to the people. The pages of this valuable book are inspired with a tone highly educational and moral; are full of the sound instruction which, as the author states, we derive now by recalling the wonderful successes gained by men inflamed with the purest patriotism, aspiring with all their energy for the liberation and glory of their country. It is expected that this fine publication will be widely diffused among all classes of the population, and will tend to perpetuate the cult of the ancient patriotism, and inspire the thoughts of the new generation.

EDWARD T. THACKERAY.

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ENGINEER RECONNAISSANCE IN UPPER BURMA.

Scale—4 Miles to 1 Inch.

96° 0′
15′
30′
22° 0′
45′
MANDALAY
AMARAPURA
SAGAING
PYINTHA
SINGAING
KYAUKSE
Pohlagôn
Shangalelyi
Sinywa
Myothit
Byingalaw
Wegyisinywa
Tadau
Panya
Sagainpanya
Taunggaing
Mondaw
Kintônpè
Thadi
Hugetkyithaik
Kongyi
Irrawaddy R.
Mandalay Palace
Fort Dufferin
Mingala Ch.
Myitnge R.
Panlaung
Sagaing Hill
Mya Lake
2447
Pyawywa
Pandaung
Welludaung
Wetyoktaung
Chaungzôn
Kyauktaw
Maingpan
Pyotha
Kalagyaung
Pyaukseikpin
Kathagon
Tazo
Magyidaw
Pindale
Aungtha
Borgwin S.
Tawdwin
Pedaw
Kyaukkan
Kyaukpyaw
Ngwedaung
Tadaingche
Onheye
Sedaw
Zibingy
Mindeyôn
Canal
Tamoksa
Sauktawwa
Mithwebôk
Nyaungbaw
Ebouk
Nyaungbintha
Ebya
Thobyeyo
Yahaunggôn
Letpanzeik
Sizôn
Ywathit
Tabetswè
Leiksangu
Paleik
Seoba
Sadaw
Danôn
Yelaung
Yetkandaw
Wayagan
Aungbinlè
Thanmadan
Letthit
Bodethân
Yema
Kingyi
Ywezu
Myathaung
Tangmataung
Chaungwun R.H.
Sakangyi
Ngwetaung
Taungkyun
Twinnyè
Zegon
Bazaar
Nyaungnè
Pakan
Kontha
Pathin
Enbôke
Nyangyintha
Sauknaingtaung
Peinnegan
Kyatwinye
Thabyegyi
Kunlein
Taungmataung
Pinsôn
Baw
Shwegyaung
Paukkaw
Maungwai
Ywaman
Leikkya
Sônbawaing
Lungaung
Yebin
Wapyudaung
Tabyewuntaung
Kyaukpontaing
Yaman
Unbinchaungtaung
Yenma Ch.
Nawade Sub Ch.
Tema
Taungma
Thondaung
Kyatpyaw
Kyuwun
Yenaung
Thandaung R.S.
Kyaukmè
Ywezu
Kyaukpyaw
Kyatpyaw
Kyauktaw
Kyaukpontaing
Kyaukgyiwa
Yelun
Sunye Tank
Shangan
Dattawtaung
Yebawgale
Ngazun
Yebaungyi
Ngedo
Thindaung
Letpan
Yanan
Kyoungbingon
Onletkauk
Kyetsha
Nanni
Onhmin
Dwehla
Singôn
Thinbôk
Pattaing
Kaungdin
Ngayodwin
Myinzaing
Indaing
Mindat
Uyingyi
Yekha
Shanywa
Hinnegu
Tawinge
Keinnayataung
Singaing
Alambo
Sawuye
Wunpade
Wuntha
Themaunggan
Tandaw
Monbingan
Ubautaung
Minhla Kan
Ywathaung
Nyaungbintha
Mithwebôk
Nyaungbaw
Pyetnaba
Kyaukmè
Mindeyôn
Tamoksa
Sauktawwa

ENGINEER RECONNAISSANCE IN UPPER BURMA.

Scale—4 Miles to 1 Inch.

96° 0′
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Maingpan
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Kalagyaung
Pyaukseikpin
Kathagon
Tazo
Magyidaw
Pindale
Aungtha
Borgwin S.
Tawdwin
Pedaw
Kyaukkan
Kyaukpyaw
Ngwedaung
Tadaingche
Onheye
Sedaw
Zibingy
Mindeyôn
Canal
Tamoksa
Sauktawwa
Mithwebôk
Nyaungbaw
Ebouk
Nyaungbintha
Ebya
Thobyeyo
Yahaunggôn
Letpanzeik
Sizôn
Ywathit
Tabetswè
Leiksangu
Paleik
Seoba
Sadaw
Danôn
Yelaung
Yetkandaw
Wayagan
Aungbinlè
Thanmadan
Letthit
Bodethân
Yema
Kingyi
Ywezu
Myathaung
Tangmataung
Chaungwun R.H.
Sakangyi
Ngwetaung
Taungkyun
Twinnyè
Zegon
Bazaar
Nyaungnè
Pakan
Kontha
Pathin
Enbôke
Nyangyintha
Sauknaingtaung
Peinnegan
Kyatwinye
Thabyegyi
Kunlein
Taungmataung
Pinsôn
Baw
Shwegyaung
Paukkaw
Maungwai
Ywaman
Leikkya
Sônbawaing
Lungaung
Yebin
Wapyudaung
Tabyewuntaung
Kyaukpontaing
Yaman
Unbinchaungtaung
Yenma Ch.
Nawade Sub Ch.
Tema
Taungma
Thondaung
Kyatpyaw
Kyuwun
Yenaung
Thandaung R.S.
Kyaukmè
Ywezu
Kyaukpyaw
Kyatpyaw
Kyauktaw
Kyaukpontaing
Kyaukgyiwa
Yelun
Sunye Tank
Shangan
Dattawtaung
Yebawgale
Ngazun
Yebaungyi
Ngedo
Thindaung
Letpan
Yanan
Kyoungbingon
Onletkauk
Kyetsha
Nanni
Onhmin
Dwehla
Singôn
Thinbôk
Pattaing
Kaungdin
Ngayodwin
Myinzaing
Indaing
Mindat
Uyingyi
Yekha
Shanywa
Hinnegu
Tawinge
Keinnayataung
Singaing
Alambo
Sawuye
Wunpade
Wuntha
Themaunggan
Tandaw
Monbingan
Ubautaung
Minhla Kan
Ywathaung
Nyaungbintha
Mithwebôk
Nyaungbaw
Pyetnaba
Kyaukmè
Mindeyôn
Tamoksa
Sauktawwa

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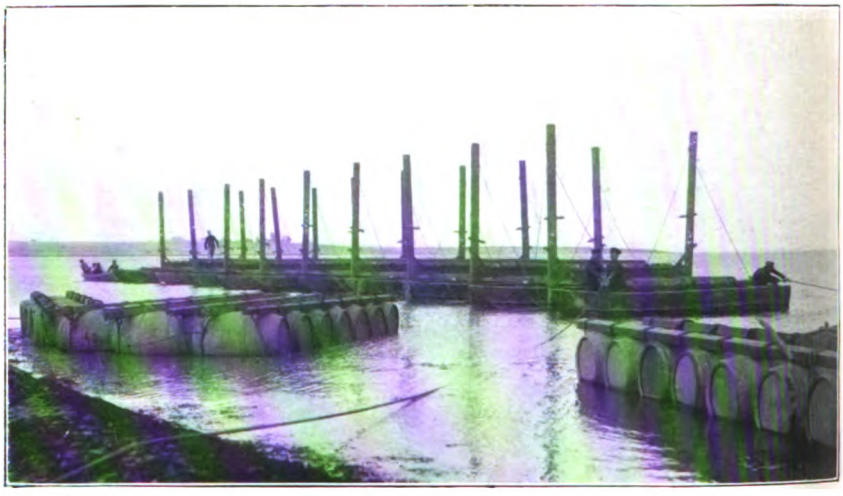
BRIDGING AT HARTY FERRY.



No. 2.—Pontoon Trestle being warped into place.

No. 3.—Loaded Transport Raft.

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BRIDGING AT HARTY FERRY.

No. 1. —Completed South Pier.

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BRIDGING OPERATIONS AT HARTY FERRY.

By MAJOR J. C. MATHESON, R.E.

DURING the Territorial Manœuvres last summer it was necessary to arrange for the crossing of troops over the Swale at Harty Ferry. The width from bank to bank was about 1,200 yards and there was not sufficient material to cover the whole, so that it was determined to run piers from either bank far enough out to be available for ferrying at all stages of the tide. The rise and fall averaged 14′, and the slope of the foreshore was very gradual so that long piers were required. The river bed was mud of the worst description.

The piers were of ordinary construction and call for little comment, but it was inevitable that in bridging operations of this magnitude a number of lessons should be learnt by the officers in charge, which may be of some service to others.

On the south bank the pier consisted of the following :—

(*a*). 108′ of approach ramp at 1 in 12 to get up to the top of the sea wall, carried on 8 lashed spar trestles.

(*b*). 108′ of pier starting from the sea wall, carried on 9 lashed spar trestles.

(*c*). 225′ on 14 pontoon trestles.

(*d*). 130′ on 13 barrel piers.

(*e*). 450′ on 30 pontoons.

(*f*). A pier head of double pontoons, giving 30′ by 15′ floor space.

On the north side there were 195′ of approach over uneven marshy ground, the transoms being carried on small cribs. Then the pier proper consisted of the following :—

(*a*). 96′ on 8 lashed spar trestles.

(*b*). 210′ on 13 pontoon trestles.

(*c*). 160′ on 17 barrel piers.

(*d*). 370′ on 24 pontoons.

(*e*). A pier head similar to that on the south side.

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Including the approach on the north side, the length of the two piers was just two-fifths of a mile.

On the west side of the piers a narrow hard ran down to low-water mark on either side. This had to be left unobstructed for the use of horse boats and the ordinary traffic of the ferry.

The working party for the operations consisted of the three works companies of the Kent (Fortress) R.E. (T.) under Major Stephens, which furnished about 150 men for work, and, after two days, 100 men of the Training Battalion, R.E. The south pier was completed by the Kent (Fortress) R.E. (T.) who also made and placed the lashed spar trestles of the north pier, the remainder being done by the men of the Training Battalion. The whole of the bridging was in charge of the staff of the Fortification School, S.M.E., which furnished 3 officers and 5 Q.M.S. instructors.

The work was carried on in daylight only, in two reliefs of about six hours' actual work each. Excluding the time taken in unloading stores, the south pier took about 4,700 man-hours and the north 3,000.

The river crossing was made use of on August 2nd, when the 4th London Brigade and some details—about 2,000 strong altogether—with 30 wagons of all sorts and 140 horses were passed over the Swale from Harty to the Faversham shore. Most of the men were ferried between the pier heads in naval launches and cutters towed by picket boats. The remainder together with the horses and wagons were conveyed on pontoon transport rafts towed by W.D. steam launch or naval picket boats.

The day was fine but a strong S.W. wind was blowing raising a considerable sea. This prevented any use of the horse boats which had been provided, and very considerably hampered the embarkation at the north pier head as the cutters and picket boats were constantly getting driven on to the pontoons, and the wind and strong tide made it very difficult to get them off. For about two hours at low water practically no ferrying could be done as every steamer was aground. The only casualties that occurred were (i.) the couplings of a pontoon of a transport raft tore out, and (ii.) a pontoon trestle leg suddenly sank 3′ under a specially heavy wagon. The first necessitated the replacement of the pontoon which took some time, the second was put right in 15 minutes.

The points of interest which arose may be classified under various heads.

I.—Lashed Spar Trestles.

(*a*). The inferiority of rope lashings as fastenings was again exemplified. Many lashings required wedging up after some days and

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others worked so loose that the bridge became distorted, necessitating strutting and in some cases re-making.

(*b*). The legs of the trestles were placed vertically. This was done because the height was not great and the ground was so irregular that separate sections were required for each line of legs. Time was pressing, and it was a simpler and quicker matter to take accurate sections in a vertical than in an inclined plane. At the same time vertical legs have the disadvantage that any racking of the frame causes one leg to lean outwards. This would probably only happen with doubtful fastenings like rope and when it has to be used it is better to keep to the sloping legs.

(*c*). On account of the mud, double ledgers were used with plank shoes nailed to the bottom of the legs and also lashed to the ledgers. This arrangement acted well.

(*d*). The longitudinal struts were butted against pieces of sheeting driven into the mud at low tide at right angles to the line of the strut.

II.—Pontoon Trestles.

(*a*). These again proved their efficiency and handiness. The new cupped shoes are distinctly preferable to the old wooden ones.

(*b*). A few of these trestles were raised from the ground at low tide, but the majority were put into bridge by the method described below, devised by Capt. Sankey, R.E.

A raft of pontoons at normal interval, with superstructure of baulks only, was brought alongside the hard which ran out on the west of the bridge. The raft had one more pontoon than the number of trestles to be raised. Then at low tide a trestle was placed in the centre of each bay and retained in a vertical position by guys on the pontoons, the transom, which was kept well down on the legs, resting on the baulks. The roadway of the trestles was then completed. When the tide rose, the raft was warped into position at the head of the bridge and the roadway connected up. Starting from the inshore trestle the legs were then lowered to take the ground, the transoms raised, and the pontoon raft dismantled piecemeal. Where conditions similar to those at Harty obtain, *i.e.* a number of trestles to be placed, available pontoons and a convenient place for loading the raft, this method would seem to be more expeditious than any other.

(*c*). As these trestles formed part of a tidal ramp the transoms had to be raised and lowered frequently. When the tide was up, some difficulty was found in manipulating the clamping arrangements of the straps, as there is no place for a man to stand or sit where he can get conveniently at the strap ends. A boat if available can be

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used, but it might be possible to sling or fix permanently a seat or step on the outside of the leg at the convenient height. On this occasion a horizontal spar was lashed to uprights driven into the river bed parallel to the bridge and about 18″ from it. The spar was a little below the level of the grip-strap, and extended alongside the trestles which most frequently had to be adjusted.

III.—BARREL PIERS.

(*a*). It is noteworthy that most of the barrel piers made in the ordinary manner were in use for 20 days, and no difficulty was experienced from the slings or braces getting slack. None of them were adjusted during the operations.

(*b*). Several composite piers were used, made up as shown on *Military Engineering*, Part III., Pl. 43, *Fig.* 5. In every case these were most unsatisfactory and became so loose that they almost broke up. When composite piers of small casks have to be made up, and small casks are far more likely to be found than large ones, it is much better to place them as shown on *Fig.* 4 of the Plate referred to above.

IV.—PONTOONS.

(*a*). All the pontoons were service pattern except 3 experimental steel ones. They received a fairly severe trial. In the journeys from and to Upnor they were towed 50 miles well loaded with stores. During the rough weather of August 2nd some of those at the heads of the piers, especially on the north side, received repeated blows from cutters and picket-boats. At low tide many of them had to take the load when grounded on the mud. It was fortunately soft and of even surface. In spite of these adverse conditions the amount of damage and leakage was very small. All the pontoons performed the return journey in the water except two, namely the one damaged in the transport raft, and a very old one which sprang a bad leak.

(*b*). For conveyance from Upnor to Harty all the pontoons and casks were divided between two rafts made in the manner shown in the figure on p. 180, Part III., *Military Engineering*. The number of boats placed side by side was six, a spar was placed across the bows of the first six pontoons and lashed there, and the raft was towed on a bridle. As a precautionary measure, in case the weight of the raft proved too much for the front pontoons, a central wire hawser was prepared to which each set of pontoons was secured separately. It was not however found necessary to use this hawser. The length of

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the rafts made them somewhat unmanageable at times especially in shooting the narrow opening of the Kingsferry Bridge over the Swale (where both rafts bumped), but as the number of tugs was limited, it was unavoidable. On the return journey, as the bridge was broken up gradually, it was found possible and more convenient to make up rafts of six pontoons, three boats in line.

(*c*). The pontoon rafts for the transport of horses and wagons were made up in the way described in *Military Engineering*, Part III., para. 285, namely 3-boat rafts of double pontoons giving a deck space of 30′ by 30′. But this was not found to be a good plan as the centre pier naturally gets twice the load on it that the outside ones do. At Harty, during the passage of the horses, it was impossible to put up screens round the rafts on account of the wind, and the animals could not be prevented from crowding towards the centre of the deck. This reduced the freeboard of the centre pier to a very small margin and in the rough water a great deal was shipped. In one journey the strain proved too much for the bottom couplings of one pontoon, which pulled away from the side and put the pontoon *hors de combat*, necessitating that raft going out of action until the damaged pontoon could be replaced.

In cases where a larger raft than a 2-boat is required, it would be better to make it up of two 2-boat rafts side by side, and in rough water even to make the pontoons touch each other throughout the width of the raft. This will probably give large excess buoyancy, but it will destroy the wash of the waves underneath the deck and prevent water being shipped except on the outside.

V.—Pier Heads.

The pier heads were made of 2-boat rafts of double pontoons. To facilitate loading and unloading the transport rafts, three sets of cut-baulks were put on the outside of each pier head. There was just room to fit these in, but the back light saddles had to be removed. Thus three easily removable roadways were provided on to the rafts. Large fenders were required when the picket boats and heavy launches were brought alongside.

To avoid getting cables round propellers, no buoys should be used with the outside anchors and the cables should be splayed inwards. At Harty three cables got foul of propellers and caused considerable loss of time and temper.

VI.—Anchors.

The anchoring arrangements required special attention as the mud was very bad holding ground. The 112-lb. anchors had chesses

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lashed to their crowns perpendicular to the line of the flukes, and this arrangement undoubtedly increased the holding power. The cables were naturally made as long as possible. On the west of the piers, to avoid blocking the hard, small piles were used in place of anchors as far as low-water mark.

Photo No. 1 shows the completed south pier. *Photo* No. 2 shows nine pontoon trestles being warped into place on a pontoon raft, and No. 3 shows a loaded transport raft coming alongside a pier head.

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NOTES ON THE EMBARKATION AND DISEMBARKATION OF MULES.

By LIEUT. T. A. SWINBURNE, R.E.

THE following notes on embarking and disembarking mules were made by the writer whilst on an expedition to the Persian Gulf last year, and may prove of use to the readers of the *Journal.*

At Bombay the mules are walked down a gangway on to a large lighter, where they stand about in considerable disorder as there are no facilities for tying them up. The lighters are towed out to the ship and the mules are hoisted aboard by the ship's derricks. On arrival at their destination the mules are slung overboard by derricks and lowered into boats. The boats are then towed by a steam cutter as close as possible to the shore, where the beach party take charge of them, get them broadside on to land and tilt them up. The mules jump out. When the mules have to be re-embarked, they will, with a little persuasion, jump straight in if the beach is steep and the boats can get close in.

If however the water inshore is shallow and the 3′ line (to which boats can come) is far out, rafts must be used and these are constructed as follows :—

CONSTRUCTION.

The frame consists of 3″ staging lashed across 2″ planks. In order to give the necessary stiffness these planks must be doubled. Four of the floor boards out of the mule stalls on the ship are then lashed above the staging. The ribs on these boards, which will run at right angles to the length of the raft, assist the mules to get a good foothold, and it was found of some use to nail matting on to the boards, as, when wet, the latter get very slippery.

The planks are 15′ long, the staging 8′. Empty water breakers such as are carried by ship's boats are lashed along the sides of the raft to give buoyancy. Two more of these are fastened under the bows, to prevent them sinking as they are apt to do when the raft is towed through surf.

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All breakers must be placed bungs on top, as otherwise—no matter how tightly they are plugged—water will certainly get in and render them water-logged and useless. A stout towing rope is fastened to the bows.

USE.

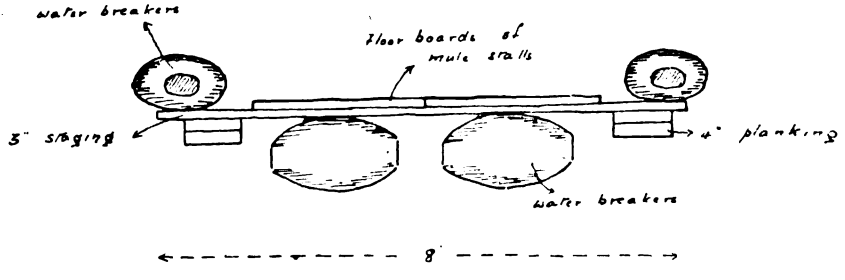
The raft may be brought alongside the ship's cutter, broadside to broadside. The mule is then walked on and made to jump in. But in order to lessen this jump and to give the animal more "run," it is better to hitch the towing rope round the thwart of the boat and slightly raise the bows of the raft, thus forming a kind of gangway. Thick mats should be hung over the gunwale of the cutter to save the mule's knees. Sapper drivers must always go with their mules in the boats.

There must be a beach party to catch the animals as they jump out. Mules on each side of the centre thwart must face opposite ways to trim the boat, as a mule always presses his hind-quarters up against the side.

A boat can be cleared of 10 mules in 40 seconds, and loaded with the same in 5 to 10 minutes. Mules can be hoisted on deck (not into hold as well) at the rate of one per minute. On one occasion 130 mules were embarked (using rafts) in 4 hours. This included $\frac{3}{4}$-mile tow, with two lifeboats and only one steam cutter.

The following are the details of the plan and elevation of the raft. The details of men and materials are also given.

END ELEVATION. (No Lashings are shown).



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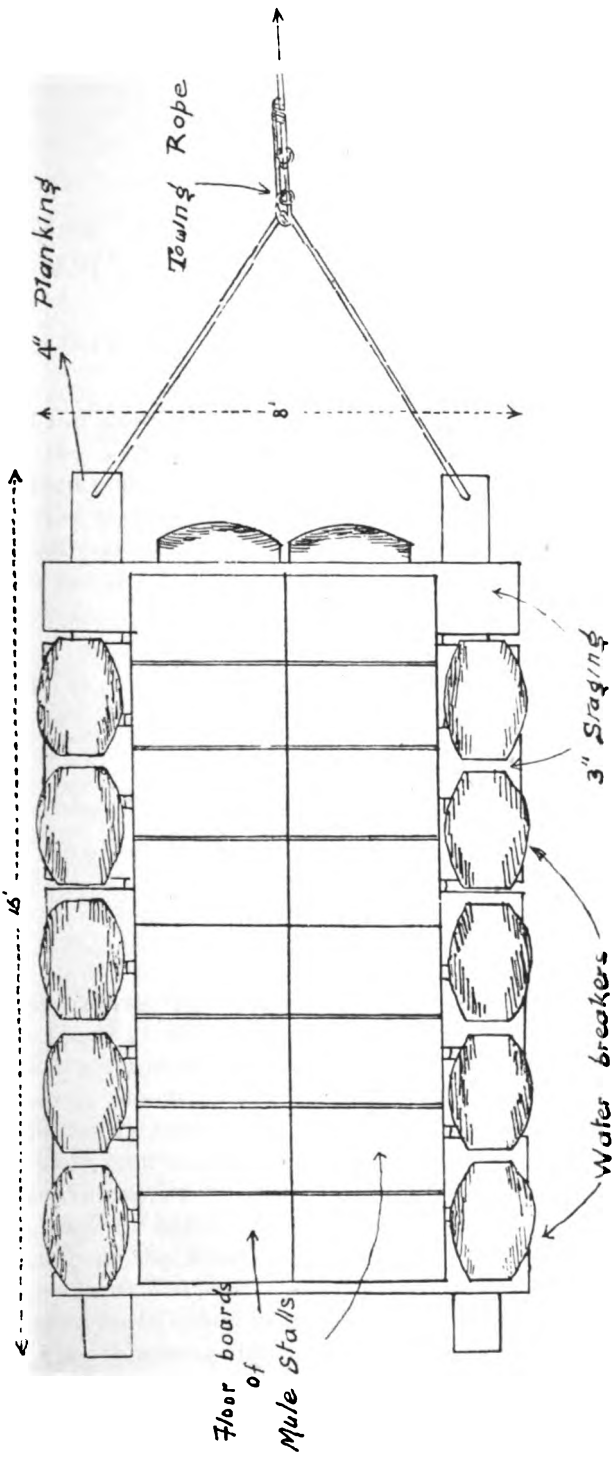
PLAN.



(*No Lashings have been shown*).

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Finally 12 men will make a raft in 2 hours and the materials required are :—

2″ planks, 15′ long	4
3″ „ 8′ „	8
Floor boards out of stalls	4
Water breakers	12
3″ rope, 20′ long	1
1″ or 1½″ lashings	40

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TERRITORIAL TRAINING OF ENGINEERS UNDER THE COMPULSORY SYSTEM IN NEW ZEALAND.

By Capt. J. E. Duigan, *N.Z. Headquarters Staff.*

Officers of the Royal Engineers will no doubt be interested in the manner that the Territorial Engineers of the New Zealand forces are to be trained under the Compulsory System of Training.

Subject to the provisions of the Defence Act, 1909, and Amendments, 1910, all male inhabitants of New Zealand who have resided therein for six months, and are British subjects are liable to be trained as follows :—

Age.	Where to Serve.	Training Prescribed.
12 to 14 years.....	Junior Cadets.....	120 hours per annum.
14 „ 18 „	Senior Cadets.....	Equivalent to 16 days.
18 „ 19 „	Territorial Force (Recruits).	14 days, 8 of which must be in camp. In addition home training which for Engineers is 20 half-days, or their equivalent.
19 „ 25 „	Territorial Force (Trained Men).	

All men on passing through the various stages of training and on reaching the age of 25 will be passed to the reserve. It will thus be seen that the system introduced although compulsory will not be any great hardship on the citizens of the Dominion.

The training in the reserve will be two muster parades per annum. It will be readily seen that under this compulsory system of training our Engineer companies will have a full trade establishment. The establishment will be based on that of the Royal Engineers, and we shall have some of the finest material in the world to work on, as pointed out by Lord Kitchener.

The system to be followed in regard to procuring men with trades will be on the following lines :—(1). They will be required to produce a certificate of competency in a list of one of the trades laid down in General Regulations. (2). Or will be tested in one

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of the workshops at the headquarters of the unit by a competent officer.

One of the most difficult questions that yet requires to be solved is the supply of officers for the various companies. As we have only four field companies the number of officers required will be few, and in my opinion the only way to ensure that the companies are well officered, is to provide in the General Regulations that only gentlemen with technical qualifications will be given commissions in the Engineers.

The peace establishment of a field company is *212*, and it remains to be seen whether so high a peace establishment can be run by our Territorial officers. The only regular staff that each company will have will be a staff sergeant-major. It should be however remembered that the Colonial learns quickly, is very adaptable, and is not so hard to discipline as some people think.

The home training will be looked on as the individual training period and the annual training in camp will be looked on as the collective training period. During the latter period of training the theoretical work learnt will be put into practice and the various companies will carry out their duties in conjunction with other branches of the service. The following is the syllabus of training laid down for field companies, and it should be noticed that the syllabus is divided into 1st, 2nd, and 3rd year subjects. Taking the organization of a field company as a headquarters and four sections, the system to be adopted is as follows :—

(1). Recruits and men with under one year's service in the Territorials will be drafted to No. 4 Section and will remain in that section until after the individual training period.

(2). Men with one year's service and less than two years' service in the Territorials will be drafted to No. 3 Section and will remain in that section until after the individual training period.

(3). Men with two years' and under three years' service in the Territorials will be drafted to No. 2 Section and will remain in that section until after the individual training period.

(4). Men who have been fully trained will be drafted to Headquarters and No. 1 Section.

The N.C.O.'s of the company will be men who have been fully trained and passed the prescribed examination. The above system will only hold good for individual training. On mobilization and for

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annual training trained men and recruits will be distributed between the sections.

The training of each section will be as follows :—

No. 1 Section and Headquarters.—General work and instructional duties.
No. 2 Section.—Third year subjects of Training Syllabus.
No. 3 Section.—Second year subjects of Training Syllabus.
No. 4 Section.—First year subjects of Training Syllabus.

Each O.C. unit will decide after the annual examination if men are to be moved up to a higher grade for the next season's training.

It will be seen that all men are put through an examination annually.

Syllabus of Training.

1st Year Subjects.—(1). Field geometry. (2). Brushwood and revetments. (3). Hasty fieldworks and earthworks generally. (4). Defence of buildings, villages, woods and improving cover. (5). Defence of posts and camps. (6). Knotting, splicing and lashings. (7). Obstacles. (8). Use of spars and hoisting gear. (9). Blocks and tackles.

2nd Year Subjects.—(10). Explosives. (11). Hasty and deliberate demolitions. Land mines. Auto. flares, etc. (12). Principles of bridging. (13). Trestle and frame bridges. (14). Pontoon and flying bridges. (15). Water supply and camping arrangements. (16). Boning and levelling. Temporary roads, etc.

3rd Year Subjects.—(17). Siege trenches, magazines. (18). Sapping and mining. (19). Defence of fortresses. (20). Preparing and firing mines. (21). Topography.

Semaphore signalling is taught during training with senior cadets.

As drivers will be procured from men who carry out those duties in their ordinary civil occupations, it is not necessary to spread their course of training over one year. The following is the syllabus for drivers :—(1). Riding and driving. (2). Field movements, limber and two horses. (3). Wagon drill. (4). Knotting, lashing and splicing. (5). Care of harness and fittings. (6). Horse management. (7). Stable duties. (8). Foot drill. (9). Semaphore signalling. (10). Physical drill.

The age of retirement of officers and N.C.O.'s is as under :—Majors, 50 years ; captains, 45 years ; subalterns, 40 years ; warrant officers and sergeants, 50 years.

The syllabus for home training is made out by O.C. units and forwarded to the Director of Training for his perusal and revision if considered necessary. Lectures are given periodically by officers on

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discipline, on the lines adopted by the Japanese, *i.e.* by appealing to the man's honour, sense of duty, and higher nature. He is taught patriotism and the objects of defence. Every sapper joining a company has issued to him a book of drills and questions and answers, the Q. & A. method of instruction having been found to give excellent results.

Having shortly described the system adopted of training in N.Z. for a field company, I think it may be fairly assumed that, when it is in full swing, the Engineer units of the Dominion will be found capable of carrying out their duties in a satisfactory manner, and fit to take the field when called upon for Imperial Defence.

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A SIMPLE FORMULA FOR CALCULATING THE STRENGTH OF REINFORCED CONCRETE BEAMS.

By CAPT. T. E. KELSALL, R.E.

IN the *R.E. Journal* for February, 1909, the following formula for concrete beams with single reinforcement was quoted from *Application of Reinforced Concrete*, by Major Stokes-Roberts, R.E.

$$bd^2 = \frac{WL}{X}$$

where b = breadth of beam in inches.

d = effective depth of beam in inches (*i.e.* from top to centre of tensile reinforcement).

W = total safe distributed load in lbs., including the weight of the beam itself.

L = length of beam in feet, the ends being supported.

X = a variable, depending on the percentage of tensile reinforcement to effective area of cross section of the beam (bd), and having values as under when mild steel bars are used.

Percentage of Tensile Reinforcement.	Corresponding Value of X.
½	45
¾	57
1	73
1½	100
2	130

The values of X appear to be obtained by equating the maximum bending moment of a uniformly loaded beam supported at the ends, with the moment of resistance of the beam for each percentage of reinforcement.

For example, taking the tensile reinforcement as 1 per cent., to find the corresponding value of X.

Working on the method given on pp. 17 to 19 of *Reinforced Concrete*, by Capt. J. G. Fleming, R.E., 1910, and adopting the values given on p. 19 for strength, etc., of steel and concrete, the formula

$$k = \sqrt{2pm + p^2m^2} - pm$$

gives the distance of the neutral axis from the top of the beam as $\cdot 42d$.

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Since 1 per cent. is more than the economical ratio of tensile reinforcement, the formula used to obtain the moment of resistance of the beam is

$$M_r = \tfrac{1}{2} kcbd^2 \left(1 - \frac{k}{3}\right)$$

which gives $110{\cdot}9bd^2$ inch-lbs. as its value.

The greatest bending moment for the beam, when uniformly loaded, and supported at the ends, is $\frac{WL \times 12}{8}$ inch-lbs. (since L is in feet and W in lbs.).

Equating, $$110{\cdot}9bd^2 = \frac{WL \times 12}{8}$$

$$\therefore bd^2 = \frac{WL}{73{\cdot}9}$$

i.e. for 1 per cent. tensile reinforcement, $X = 73{\cdot}9$.

Working out values of X, to the nearest whole number, for various percentages of mild steel tensile reinforcement, the following results are obtained.

Percentage of Tensile Reinforcement.	Corresponding Value of X.
$\frac{1}{4}$	25
$\frac{1}{2}$	47
$\frac{3}{4}$	65
1	74
$1\frac{1}{4}$	78
$1\frac{1}{2}$	82
$1\frac{3}{4}$	85
2	87

From the above it would appear that the values of X, given with the original formula for percentages of reinforcement over 1 per cent., are much too high.

If wrought iron is used as the reinforcing material instead of mild steel, the following results are obtained.

Taking the safe tensile strength of wrought iron as 11,000 lbs. per square inch and

$$\frac{\text{modulus of elasticity of wrought iron}}{\text{modulus of elasticity of concrete}} = \frac{24{,}000{,}000}{2{,}000{,}000} = 12$$

the economical ratio of reinforcement is found to be ·0107 (just over 1 per cent.), and the distance of the neutral axis from the top of the beam $= {\cdot}39d$.

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The values of X are as under.

Percentage of Tensile Reinforcement.	Corresponding Value of X.
$\frac{1}{4}$	17
$\frac{1}{2}$	33
$\frac{3}{4}$	49
1	64
$1\frac{1}{4}$	72
$1\frac{1}{2}$	76
$1\frac{3}{4}$	79
2	82

The same formula can be used for doubly reinforced beams, if the relative proportions of compressive and tensile reinforcement are fixed. The formula

$$p' = \frac{3(2pt - kc)}{4(m-1)c}$$

on p. 21 of Capt. Fleming's book gives the amount of compressive* reinforcement necessary to cause the tensile reinforcement to be fully stressed, when in excess of the economical ratio.

The moment of resistance is then obtained from the formula

$$M_r = pbd^2t\left(1 - \frac{k}{3}\right),$$

k being taken as $\cdot 36d$ and $\cdot 39d$ for mild steel and wrought iron respectively, *i.e.* the same as in singly reinforced beams with the economical ratio of reinforcement.

Values for X can then be found as before, and are as follows.

Mild Steel.

Percentage of Tensile Reinforcement of Effective Area.	Corresponding Percentage of Compressive Reinforcement of Effective Area.	Corresponding Value of X.
$\frac{3}{4}$	$\frac{1}{4}$	70
1	1	94
$1\frac{1}{4}$	$1\frac{1}{2}$	117
$1\frac{1}{2}$	$2\frac{1}{4}$	141
$1\frac{3}{4}$	3	164
2	$3\frac{3}{4}$	188
$2\frac{1}{4}$	$4\frac{1}{2}$	211
$2\frac{1}{2}$	$5\frac{1}{4}$	235
$2\frac{3}{4}$	6	258
3	$6\frac{3}{4}$	282

* Not *tensile* reinforcement as stated in the book: apparently this is a clerical error.

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Wrought Iron.

Percentage of Tensile Reinforcement of Effective Area.	Corresponding Percentage of Compressive Reinforcement of Effective Area.	Corresponding Value of X.
$1\frac{1}{4}$	$\frac{1}{2}$	80
$1\frac{1}{2}$	1	96
$1\frac{3}{4}$	$1\frac{3}{4}$	112
2	$2\frac{1}{4}$	128
$2\frac{1}{4}$	3	144
$2\frac{1}{2}$	$3\frac{1}{2}$	160
$2\frac{3}{4}$	$4\frac{1}{4}$	176
3	$4\frac{3}{4}$	191

It must be remembered that all the values of X given above are for a uniformly loaded beam supported at the ends. Consequently if the formula is used for other beams, changes must be made in the values of X inversely proportional to the changes in the bending moment.

The proper distribution of the reinforcement when the bending moment changes from — to +, as in the case of a beam fixed at the ends, must of course be arranged for, as well as provision against failure by shear.

As the writer lays no claim to be an expert in the subject of reinforced concrete, any criticisms on the above article will be welcomed by him.

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WORKS FINANCE.

By S. DANNREUTHER, ESQ.

From a Lecture delivered at the S.M.E. on 10th November, 1910.

SOME time ago the late Commandant of the S.M.E. suggested that, as a supplement to a professional lecture on Trade Accounts and the general principles of all accounting, a further lecture should be given dealing with the special features of Army Accounts and Army Finance, and for this purpose he sought the assistance of a military officer of the late Army Accounts Department, who should have had experience of work both at the Headquarters of a Command and at the War Office. No volunteer was, however, forthcoming; and I was then asked if I would undertake the task. I can lay no claim to the requisite qualifications; but as I happen for the moment to be in charge of the Works Finance branch of the War Office, it occurred to me that, although I could not deal exhaustively with the whole subject, my experience of the financial administration of the Works Vote might enable me to offer a few remarks on that part of the subject which is, or will be, of special interest to those, on whom sooner or later will devolve the important duties of a Division Officer or a Commanding Royal Engineer.

It is, no doubt, true that Works Services are for the most part peace services. When you take the field, bricks and mortar give way largely to canvas; and it is not for Works Services proper, that is to say, the designing, erection and maintenance of buildings, that the Corps of Royal Engineers primarily exists. It may well be, therefore, that many junior officers regard Works as of secondary importance, although it is, I believe, generally considered that they form an excellent preparation for Engineer work in war. They must recollect, however, that their highest functions, so important in time of war, are to a great extent in abeyance in time of peace; and as peace is the rule and war the exception, the majority will probably find a considerable portion of their future careers devoted to Works. In any case, it is almost exclusively in this direction that they will come to close quarters with Army Finance and Accounts. I shall, therefore, after a general survey of the sphere of Army Finance, practically confine myself to the financial and accounting

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aspects of Works Services; and it is to officers who will before long be Division Officers that my remarks are more especially addressed. If any have already a craving for financial responsibility, it may interest them to learn that to them, a very small body of officers when compared with the grand total of combatant officers of the Army, such responsibility will attach in a far greater measure than to any other class of officers. On Engineer officers, or rather on those of them who may be engaged on Works, will devolve the duty of expending annually, in the best interests of the State, a sum of from £1,000,000 to £1,500,000 on behalf of the War Department alone: (if we include India and Egypt, the annual aggregate will amount to £3,000,000): and they will have unique opportunities of effecting economies in designs of buildings, types of construction, employment and supervision of labour, and in other directions. Larger sums may be disbursed by others in paying, feeding and clothing the troops; but such payments are for the most part made in accordance with definite rates and scales, and do not involve responsibility commensurate with that which will fall on Engineer officers.

Now, in the first place, I must endeavour to give a brief sketch of the system of Army Accounts and the sphere of Army Finance. In the outside world of commerce, including therein the activities of County Councils and other municipal bodies, the term "finance" is usually applied to such operations as the raising of capital and other funds, and the buying and selling of stocks and shares. With such finance we in the War Office have nothing to do. Whatever funds are allotted to the Army by Parliament are raised, whether by taxation or from other sources, by the Chancellor of the Exchequer, and placed in the hands of the Paymaster-General from whom we draw cash in accordance with our requirements, up to the total amount allotted to us. By Army Finance must be understood such rational control as is exercised by the Army Council over estimates and expenditure. How difficult a matter it is to exercise an effective control will be more apparent when the somewhat anomalous system of Army accounting is thoroughly understood.

That system dates from the Revolution of 1688, or rather from the definite establishment of the principle, embodied in 1689 in the Bill of Rights, that "the raising or keeping of a standing army in time of peace, unless it be with the consent of Parliament, is against law;"—words which are repeated every year in the Preamble of the Annual Army Act. The compact then made between the Crown and Parliament provided that a standing army should be kept at such strength as Parliament might authorize, and that, while the command should vest in the Crown, the money should be provided by the House of Commons. In the long constitutional struggle this was a great victory for the Commons; but there was still no guarantee that the money so provided by them would not be misappropriated,

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and history shows that such misappropriations were not infrequent. By misappropriation I do not mean merely malversation, peculation, or any similar offence, but also the technical offence of expending the supplies granted by Parliament on other objects than those specified by Parliament. It was mainly to guard against the latter offence that a special form of accounts was devised and public auditors were appointed. The accounts, called Appropriation Accounts are, as their name implies, primarily intended to show that the money spent has been correctly appropriated to the specific purposes for which the various grants to the King have been made, and they are the only accounts demanded by Parliament. The scope of the public audit was gradually extended; and the powers and duties of the Comptroller of His Majesty's Exchequer and of the Commissioners for auditing the Public Accounts were finally consolidated by the Audit Act of 1866. The Comptroller and Auditor-General is a public official in an exceptional position in that he is directly responsible to the House of Commons, and is not dismissible by the Government. He reports to the Public Accounts Committee of the House, a distinguishing feature of which Committee is the fact that its Chairman and the majority of its members are drawn from the Opposition.

The settlement of 1688 still holds good in its main principles, though in practice the constitutional claims of the Crown have, through disuse, suffered considerable abatement. The Sovereign retains supreme command of the Army, but exercises his control through the Secretary of State for War, who is responsible to Parliament for his own acts and for the advice he gives. Real executive authority resides now, in theory, in the Privy Council—in fact, in the Prime Minister and his Cabinet.

Now to turn to the form of Army Estimates and of the corresponding Appropriation Accounts. I advise those who have never studied them to get specimen copies of each: a first glance will be sufficient to show how markedly they bear the impress of that principle of "appropriation" by which in former days the people's representatives set such store.

In the forefront of Army Estimates appears Vote A: this is not a money vote, but deals with the numbers of officers and men on the Home and Colonial Establishments. It owes its origin to the settlement of 1688, under which the King was authorized to keep a standing army at such strength as Parliament might approve; and the vote must be taken every year in Parliament to make it lawful to maintain any standing army at all.

Vote A is followed by the money votes, at present 15 in number, those numbered 1 to 12 dealing with effective services, and the last three, numbered 13 to 15, dealing with the non-effective charges for officers, for men, and for Civil Servants and other civilian subordinates.

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The votes for the non-effective services do not call for any particular comment: the rates or scales of pension, etc., are more or less definitely laid down in the Royal Warrant for Pay or in Acts of Parliament, and the procedure in regard to these votes is, to a great extent, automatic. The annual aggregate net expenditure under them amounts, however, to nearly £4,000,000; and in considering the financial aspect of any new proposal, care has to be taken not to omit from the calculation any future so-called "non-effective" charges.

The 12 "effective" votes provide successively for the following services:—Pay of the Army (including, by the way, the cost of the Establishment of the School of Military Engineering); Medical Establishment; Special Reserves; Territorial Forces; Establishments for Military Education; Quartering, Transport, and Remounts; Supplies and Clothing; Ordnance Department Establishments and General Stores; Armaments and Engineer Stores; Works and Buildings; Miscellaneous Effective Services; and, finally, the War Office.

Each of the money votes is divided into a number of subheads, of which there are in all nearly 200; and these subheads are generally further subdivided into innumerable items. The important point to notice is that each vote and each subhead of a vote deals with expenditure of a particular nature, and not with expenditure directed to a particular object. For instance, there is in the Supplies Vote a subhead to provide for the cost of fuel and light—and so, if we buy anything in the nature of fuel it can only be charged to this particular subhead, though the use to which it will ultimately be put may be, in one case, to cook the soldiers' food, in another to heat a copper for washing, in another to produce steam for driving machinery, and so on. It may be taken as a general rule, to which there are only a few minor exceptions, that Army Estimates ignore purpose, and are based on classification in accordance with the immediate character of the expenditure.

The Appropriation Accounts follow the estimates in every detail of form (it would perhaps be nearer the truth to say that the estimates follow the accounts, as it is the necessity for presenting Appropriation Accounts that conditions the form of the estimates). The total of every class of expenditure, vote by vote, subhead by subhead, and in some cases item by item, is shown in direct comparison with the estimate, *i.e.* with the specific grant of money voted by Parliament. I need hardly point out that the system has one obvious advantage from a book-keeping point of view. There is not much room for doubt as to the immediate nature of any item of expenditure; it can therefore readily be charged to the correct vote and subhead, without the delay and uncertainty that would arise if in each case the ulterior object had to be ascertained.

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No excess on the total of Army Votes is permissible; if any occurs, it must be met by a Supplementary Estimate. An excess on one vote may only be met by a saving on another vote with the provisional sanction of the Treasury, subject to ratification by Parliament itself by means of a clause in the Annual Appropriation Act. Within the confines of a single vote none but a trifling excess on any subhead may be incurred without the sanction of the Treasury; and the same rule applies occasionally even to individual items under a subhead.

Such is the system of control devised by Parliament, a control rigidly exercised with the aid of the Exchequer and Audit Department. It may be summed up in the one word "Appropriation." There is an important corollary to which I have not yet alluded. The Parliamentary grants are made for expenditure on particular objects during the particular year, and the appropriation of the money granted is shown in the accounts for that year. It follows from this that, if the Parliamentary control, such as it is, is not to be impaired, no carry-over can be allowed. It is in fact a cardinal point in our national system of finance that, except in the case of loans for which special provision is made by Acts of Parliament, the expenses of any one financial year (from the 1st April to the following 31st March) must be met from the revenues of that year; any unspent balances being surrendered to the Exchequer and normally applied to the reduction of the National Debt. Liabilities incurred must be discharged in the year in which they mature from the funds voted by Parliament for that year. In short, every financial year is a water-tight compartment.

There are administrative difficulties due to this restriction. They are especially prominent in the case of Works which can rarely be executed in their entirety within the limits of any one financial year. But the restriction is, I think, inherent in, and inseparable from, the existing system of Parliamentary Estimates and Accounts.

Critics of the system are not wanting, even among those who are aware of the difficulty of finding any satisfactory alternative. Here, for instance, is a recent comment of an ex-Cabinet Minister:— "Operations have to be terminated or postponed, surpluses surrendered, deficits avoided, quite irrespective of the business aspect of the transaction, to fit in with the pedantry of Appropriation Bills and other antiquated methods of supervising expenditure." Moreover I must point out, what indeed is obvious, that the system, while affording an adequate safeguard against misappropriation, in both its natural and its technical sense, and at the same time admitting of simplicity in the matter of book-keeping, is incomplete in that the accounts do not, like commercial accounts, afford any direct evidence of economy in administration, nor is the form of the estimates such

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as to enable the House of Commons to exercise any efficient check on extravagance.

"How unbusinesslike!" the reader may exclaim. "Shall we never have ordinary business methods introduced into the financial administration of the Army, one of the largest, if not the very largest, business concerns in the British Empire?"

A very plausible complaint—but I must point out, in the first place, that the limited nature of Parliamentary control does not imply that there is not an adequate departmental control; and, secondly, that ordinary business methods (that is to say, commercial methods) are in reality inapplicable, at least in their essential features. I do not mean to say that we cannot, and do not, follow such business methods in our commercial transactions—as, for example, in the management of our factories or in our administration of contracts—but all such transactions are only incidental to the real business of the War Office, which is to maintain and add to the efficiency of the nation's fighting machine.

Now in business, as it is understood in the world of commerce, the one primary object in view is to obtain, for a given cash expenditure, a greater cash return; and the success of an undertaking is gauged by the proportion that the return bears to the expenditure. The central pivot in the controlling mechanism is the Profit and Loss Account. If a satisfactory profit can be assured, further funds will readily be forthcoming; and the concern and its capital may continue to grow, almost indefinitely. As with the whole, so with its parts: in any branch, however small, an increase of expenditure will be welcomed, provided that the rate of profit be not diminished; and considerable freedom of initiative can be allowed to a manager, however subordinate, provided always that its exercise result in a satisfactory cash return—and of this there is a never-failing index in the accounts. Liability to be called to account must always attach to true responsibility; and where there is true responsibility, decentralization presents few difficulties.

Turn now to the business of the Army. There is a steady demand for cash expenditure—but the return that we have to look for is not in cash, but in that somewhat intangible commodity, military efficiency. This efficiency is to a certain extent a matter of opinion; the only real test that can be applied to it is the test of war, and, happily, that test is rarely applied. There is no accurate index-meter in the shape of a Profit and Loss Account.

Although we can say that, provided there is no waste, a greater expenditure may lead to greater efficiency, there is obviously a limit to the amount that any nation can afford to spend on the maintenance of its security in time of peace. Within that limit there is only one way of attaining the maximum of efficiency, and that is by

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practising rigid economy. Therein lies the true function of Army Finance.

I should like in this connection to quote the happily expressed opinion—not of a civilian, whom some might think prejudiced, but—of a distinguished member of the Royal Engineers, the late Commander-in-Chief in India. "A modern army," he recently said, "is simply an insurance against national disaster; and the expenditure incurred on it is strictly comparable with private expenditure on similar precautionary measures. The first business condition necessary to justify our military expenditure is that the army maintained should be in a thoroughly efficient state. . . . Expenditure of money on an inefficient army can no more be defended than the payment of premia to an insolvent company. . . . But the application of business methods to Army administration means more than this. It means that we must never for one moment lose sight of the fact that the efficiency of an army maintained as the ultimate guarantee of public security must be purchased at the lowest possible price. Therefore every existing source of Army expenditure has to be periodically scrutinized, and be shown to contribute towards that security or be discontinued; and the cost, as well as the utility, of every proposal for new expenditure must be most carefully considered before it is accepted."

In this consideration—in the pursuit of economy—lies, as I have said, the function of Army Finance. It is not confined to the Finance Department, but is the constant preoccupation of the Army Council and its subordinate officers.

From what we have seen of the structure of Army Estimates and of the form of the accounts there is no difficulty in realizing that it is no easy matter to ascertain the exact financial effect of any new proposal for increased expenditure. The prime charge on the vote immediately concerned may not be difficult to calculate; but there are nearly always indirect effects on other votes which cannot easily be disentangled by anyone who has not acquired a familiar knowledge of estimates and accounts. It is the special duty of the Finance Department—the main permanent element of the War Office—to acquire such familiar knowledge, with the power of criticism which it bestows, and to place it at all times at the disposal of the members of the Army Council and their Military Directors, so as to enable them to exercise a rational control.

Hitherto my references to Army Estimates have been to them in their Parliamentary form. We must now go back to their earlier stage, the stage of preparation before they are presented to the House of Commons. The first step towards their preparation is to ascertain the total amount of money that will be available for expenditure on the Army during the course of the year. That total is fixed by the Cabinet. After making allowance within that total for all

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absolutely necessary and unavoidable services, there will normally remain a margin to be devoted to new services at the discretion of the Army Council, subject to Treasury concurrence in the case of any new departure or in the event of recurrent expenditure being involved. The claimants to a portion of this margin are innumerable; and the definition of their order of precedency is one of the most important duties of the military members of Council, as it rarely happens that the margin is sufficient to admit more than a percentage, a very small percentage in the case of Works Services. To take the Works Vote alone, one pressing need may be for the provision of new infantry barracks at Chatham, another for the general provision of dining rooms, another for the purchase of new training areas and the construction of new ranges, and so on; and it may be that these various claims have to be considered not only on their merits as between themselves, but in competition with extraneous claims, under other votes, such as, for example, the need for an increase in the establishment of horses, for the annual issue to the soldier of an extra shirt or an additional pair of boots, or for a special grant for manœuvres on a large scale. Moreover in the case of each item consideration must be given not only to the effect on the estimates then in course of preparation but also to the effect on the estimates of future years; for as in private life, so also in the affairs of the State the old maxim holds good: "A Man ought warily to beginne Charges, which once begun will Continue; But in Matters, that returne not, he may be more Magnificent."

When a settlement has been made of these conflicting claims, the estimates for the year, after submission to the Treasury, are presented to Parliament. As soon as they are passed, the funds voted are placed at the disposal of the Army, and the financial consideration of estimates gives way to the financial control of expenditure.

Let us examine for a moment the method of this control, which embraces the greater part of the field of Army administration, as there are but few spheres of military activity which do not involve expenditure. Owing to the uncommercial nature of our return, the accounts cannot be made to furnish a commercial test of economy; practically the only measure of economy is the amount of expenditure, which must therefore be watched and controlled with much greater care than is necessary in an ordinary business undertaking. I may here point out that for this purpose the existing system of accounts suffices. That system has, moreover, as we saw before, the great merit of simplicity. On the whole, therefore, I think that we would now be justified in coming to the conclusion that the Appropriation Accounts, though at first sight anomalous in character, are not in reality irrational, and that a more scientific system would not prove to be of sufficient practical utility to justify the very consider-

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able extra trouble and expense that its adoption would necessarily involve.

To return from this digression—efficiency has no cash equivalent; and, in the absence of accountability in its commercial sense, true financial responsibility is, in nearly every case, impossible. This consideration is sufficient, I think, to convince us that we cannot escape recourse to regulations, not merely as a guide to administration but also as an instrument of control.

The money voted by Parliament takes the form of a grant to the Crown, limited in total amount and in regard to the total of each vote and subhead, and subject to the rigid rules of "appropriation." It is the duty of the Treasury to ensure the fulfilment of these conditions, and in a general way to check extravagance; and it carries out this duty by imposing on the War Office regulations from which no departure is permissible without their Lordships' sanction, and requires annually from the Accounting Officer for the Army a certificate that these regulations have been duly observed. The post of Accounting Officer is held by the Assistant Financial Secretary, the permanent head of the Finance Department, with definite functions laid down in an Order in Council; and is a post to which genuine responsibility attaches, inasmuch as the Accounting Officer has to appear every year before the Public Accounts Committee of the House of Commons to answer for the whole expenditure of the Army and to defend his own actions and those of his subordinates against any criticisms that may be made by the members of that committee with the aid of their own official, the Comptroller and Auditor-General.

The War Office in turn imposes its own regulations on the Army, to enable it, in the first place, to discharge its responsibilities to the Treasury and to Parliament, and, secondly, to discharge its own responsibilities in the way of securing economy and thereby increasing the efficiency of the Army as a whole.

Regulations are a nuisance. Nobody likes them. Moreover no amount of regulations can in themselves engender a true spirit of economy or ensure efficiency in administration. We should certainly eliminate all that are unnecessary; but we cannot dispense with regulations altogether or to any great extent. On the administrative side, a certain measure of uniformity is indispensable; on the financial side, in view of the considerations I have mentioned, it will, I think, be readily admitted that a free hand, except within well-defined limits, is impossible. In the absence of accountability—and in our uncommercial business it is so often absent—the free hand can only spell irresponsibility. Those outside the War Office may occasionally chafe under War Office regulations, as we do under Treasury regulations; but if their abolition would lead to irresponsibility it is better for the average man that they should not be abolished. He must

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console himself with the argument that has been adduced in support of the principle of a Second Chamber, that it is mentally, morally, and politically bad for the holders of power to have none whom they must consult. Moreover the necessity for stating one's case conduces towards clear thinking, and often reveals an unsuspected weak spot in either premises or conclusions.

It is customary nowadays to preach the gospel of decentralization. Its merits are undoubtedly great, but should not be exaggerated ; and I must enter a caveat against the indiscriminate condemnation of the principle of centralization, to which it is opposed. Centralization is an ambiguous term. It is sometimes used to convey the idea that local authorities are being hampered by the central authority ; in that sense it is to be deprecated. I should prefer to define it as the arrangement by which the various local authorities are brought into proper contact with one another and with the central authority. Such centralization is indispensable, if chaos is to be avoided. We must recollect that the British Army organization is necessarily centralized. It is not a federation of local armies ; and uniformity may often be a greater gain than independence.

Although our method of control is not on commercial lines, the machinery through which it is exercised bears a general resemblance to that obtaining in the world of commerce. In every business concern comparable in magnitude with the business of the Army there are five distinct elements, each one of which has its own functions, while the co-operation of all is essential to the successful working of the undertaking. There are the shareholders or owners ; the directors ; the managers ; the accountant ; and the auditor. The shareholders find the money, and with the auditor settle the form of the accounts which are checked by the latter on their behalf. The corresponding elements in the Army system are the House of Commons, and the Comptroller and Auditor-General. The Directors—in our case, the Army Council—decide all questions of policy, the execution of which is left to the managers, who in the Army organization are represented by the General Officers Commanding. Lastly there is the accountant or internal auditor corresponding to our Accounting Officer with his subordinate officials at the War Office and in the commands. It is important to notice that in large businesses the accountant is distinct from, and independent of, the managers. A manager, for instance, may have a free hand in buying and selling, and sign the invoices ; but he does not keep the accounts. If this separation of functions is found to be necessary in the world of commerce, the necessity is still greater in the case of the Army, where economy cannot be gauged by a Profit and Loss Account but has to be measured in each case by the total of expenditure, and the real cost of any operation cannot without difficulty be extracted from the accounts. Our managers, like all managers, are—or at any rate

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should be—enthusiasts, and *pro tanto* unreliable. The accountant, on the contrary, should be a cold, dispassionate outsider, concerned only with facts.

Now when once the estimates have been passed, the Military Departments have power to authorize, without previous reference to the Finance Department, all expenditure covered by regulation and provided for in the subheads of the estimates. Within these limits the Military Directors at the War Office and the General Officers Commanding have a free hand. In large commands the General Officer Commanding-in-Chief is assisted by a General Officer in Charge of Administration, who is charged with direct responsibility to the War Office on financial subjects.

When expenditure is incurred, it must be duly certified by the responsible officer; payment is then made by the local paymaster, and if no objection arises on internal audit the charge is incorporated in the accounts which are finally summarized in the central ledgers of the War Office.

For some years past, under the reorganization scheme adopted on the recommendation of Lord Esher's Committee, the pay, accounting, and internal audit services of the Army were merged in one comprehensive Army Accounts Department; but a reversion has now been made to the previous system under which the local pay and accounting services are performed by an Army Pay Department, a military administrative department under the General Officer in Charge of Administration, while audit is entirely separated and assigned to a civilian Local Auditor, representing the Accounting Officer of the Army. The authority of the Local Auditor is derived from that of the head of his department, whose functions, as I have already mentioned, are defined by an Order in Council, which is of sufficient importance to justify quotation in full:—"The Assistant Financial Secretary to the War Office shall act as deputy and assistant to the finance member of Council and shall advise the administrative officers at the War Office and in commands on all questions of Army expenditure. As the accounting officer of Army votes, funds, and accounts, he shall be charged with the allowance and payment of all monies for Army Services; with accounting for and auditing all cash expenditure and preparing the annual accounts of such expenditure for Parliament; and with auditing all manufacturing, expense, supply, and store accounts."

With this quotation I have come to the end of the general survey of the system of Army Accounts and the sphere of Army Finance. I propose now to devote the remainder of the space at my disposal to particular aspects of the question, relating especially to Works Services, and to offer a few general remarks on Contracts and on Storekeeping. They may appear to some to be in the nature of platitudes; but their recognition of them as such will, at least, show

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that they have already grasped the principles embodied in them and will not fail to apply them when they are called upon to deal with concrete cases.

In the first place it may be of use to run through a typical estimate of Vote 10, the Works Vote, subhead by subhead, showing thereby the structure of the vote, and at the same time to point out the various spheres wherein special responsibilities will be found to lie. Let us take the vote for the current year, amounting to a net total of £2,598,000 spread over 12 subheads.

Subhead A provides for the specialized staff or establishment for Works and Engineer Services at a total cost of £183,000 exclusive of the pay and allowances of Royal Engineer officers and of all staff employed at the War Office or on services chargeable to the Military Works Loan. In the sum of £183,000 are included the consolidated emoluments of civilians and pensioners, but only the pay in the case of such serving soldiers as Military Foremen of Works, Engineer Clerks, etc. In the case of the latter, in accordance with the general system of Army Estimates, lodging allowance, provisions, clothing, non-effective charges, etc., are provided for under the appropriate votes and subheads. Furthermore, this staff subhead does not cover the cost of offices and fixtures, nor of their heating and lighting; while all materials that come under the comprehensive heading of stationery are issued free of charge by His Majesty's Stationery Office. These considerations suffice to show that the real cost of our Works Staff is high, no doubt unavoidably so; but the tendency to increase which it exhibits is a constant source of anxiety to the War Office. The amount of work in any district is always fluctuating, and temporary increases of staff are unavoidable; but we rely on officers, as co-trustees of the public funds, to make reductions whenever and as soon as opportunities occur, and only to apply for extra assistance when the absence of such assistance would be really prejudicial to the interests of true economy. We should imagine ourselves to be in business on our own account, and consider in each case what the effect of the extra cost would be on our profit and loss statements.

Subhead B provides £16,000 for the incidental expenses of lands producing revenue—in other words, for the expenses incurred by the War Department in its capacity as landlord. The rentals, about £44,000, a year, are credited to Subhead L, to which we shall come later on. As a rule we do not receive full commercial rents owing to the lettings being subject to military user or to other restrictions due to military requirements. I may here point out that there has recently been established at the War Office a separate branch under a Comptroller of Lands, whose functions are exclusively to deal with the administration, purchase, and sale of War Department property. The local administration devolves on the Royal

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Engineers, and is for the most part concentrated in the offices of the Chief Engineers of the commands, assisted in special cases by land agents.

Subhead C provides for telegraph, telephone, and signal services:— £13,500 of which the main item is £12,000 for construction and maintenance services. This subhead provides only for military exchanges and circuits; the work being executed locally by the Engineer officer in charge of telephones out of funds allotted by the War Office. The rentals for connections to civil exchanges are not chargeable to Vote 10, but to the vote which provides generally for postal and telegraphic expenses.

Subhead D provides £20,000 for miscellaneous Engineer services, the principal items being £11,000 for experiments and £6,400 for the Works charges for temporary camps for the Special Reserves.

We now come to the main subheads of the vote, those for Works Services proper. These subheads, formerly nine in number, have this year, I am glad to say, been reduced to three, viz.: E, F, and G. They cover the three main categories, known as Parts I., II., and III., into which works are divided. Under Part I. come new works, alterations and repairs, estimated to cost £2,000 and upwards, while Part II. comprises new works and alterations estimated to cost less than £2,000, and Part III. provides for ordinary repair, renewal, and maintenance services, costing less than £2,000. I should add that in some cases a Part I. item may provide for a programme of similar services to be executed at various stations, costing individually less than £2,000, but amounting in the aggregate to a large sum. Such items are known as "General Items."

Each Part or Subhead comprises three divisions—(prior to the present year each of these divisions formed a separate subhead of the vote)—devoted respectively to Fortifications and Artillery Ranges, Army Ordnance Buildings, and Barracks. Under Parts II. and III. the aggregates only for each division are given; but under Part I. each item is shown separately and a specific sum voted therefor by Parliament for expenditure in the current year. Under the system of Parliamentary and Treasury control, which I have already described, no material excess may be incurred on any subhead or on the total estimate for any individual Part I. item; nor may any new Part I. item be opened without the prior sanction of the Treasury. As there are about 100 Part I. items and the progress on any particular service cannot be accurately forecasted, owing to the uncertainty attaching to foundations, to the weather, and to the efficiency of a contractor, there is inevitably considerable difficulty in making the expenditure within the hard-and-fast limits of a financial year approximate to the estimate. This was recognized by the Committee on War Office Organization, which sat in 1901, and recommended us "to rearrange the Works Vote, so as to secure

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greater elasticity, and to carry over unexpended balances, in order to prevent a tendency to wasteful expenditure at the close of the financial year."

Now the principle of carrying over unexpended balances is opposed to the Parliamentary system of controlling expenditure, and has proved impossible of application. We have, however, made it our constant endeavour to secure greater elasticity in the financial administration of Works Services. For some time past a General Officer Commanding has been empowered, in the case of a Part I. service, to incur an excess on the provision for the year provided that the total estimate is not exceeded and that the excess is counterbalanced by savings in the year on other Part I. services within the same command; and now, in this very year, the War Office has at last been empowered to extend the application of this principle generally to all Part I. services irrespective of the separate commands; and it is by this extension of the practice of transferring savings to meet excesses on the provision for the year, provided that the total estimates sanctioned by Parliament are not exceeded, and by the simultaneous reduction in the number of subheads and of the limitations which they involve, that we hope to have obtained sufficient elasticity in administration to make the aggregate annual expenditure on Part I. services correspond closely to the aggregate estimate—a task in which we have hitherto signally failed.

The annual expenditure under these Subheads E, F, and G amounts to a very large sum. In the year which we are considering the estimates have provided for an expenditure of over £550,000 on Part I., over £216,000 on Part II., and £535,000 on Part III. services —the total provision amounting to over £1,300,000. From these figures it is obvious that the financial progress of the Works under the charge of the Engineers will need to be closely watched, and that great care will have to be taken to render accurate the forecasts which they are called upon to furnish to the Army Council to enable the latter to control the course of Army expenditure as a whole.

For all these services allotments of funds are made by the War Office to the headquarters of the commands, for subsequent distribution by the Chief Engineers to their subordinate officers. They must on no account be exceeded without special authority; and if savings of any magnitude occur, they should be reported as early as possible. It is necessary therefore for officers to keep accurate records of all allotments made to them and of their expenditure thereunder. These allotments are not, of course, actual allotments of cash; that is found by the paymaster who pays the bills on their certificate. They are authorizations to the Engineer officers to incur expenditure on specified services up to the limits fixed, and are made to them as the officers responsible for controlling the expendi-

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ture. They hold good only for the financial year in which they are granted.

I will defer till later a few remarks which I wish to offer on the nature of the certificates which officers have to give and their responsibility in connection therewith; but before passing on to the consideration of the remaining subheads of Vote 10, I must draw attention to the immense financial, as apart from accounting, responsibility that attaches to the officers of the Royal Engineers in respect of Works Services—a responsibility which I do not think has always been adequately realized in the past. Correct accounting, accurate forecasting, and a rigid adherence to regulations may simplify administration, and bring about indirect savings; but in connection with Works, which are in their nature expensive, the real source of economy is to be found in the designs of buildings and the types of construction. The thoughts of those who were at the S.M.E. last winter will naturally revert to the interesting lectures on Works Economics by Brigadier-General Scott-Moncrieff, with whom I had the happy experience of working at the War Office before he took up his present appointment of Chief Engineer at Aldershot. They may recollect that he divided the Science of Engineering Economics into two broad classes, the Economics of Policy and the Economics of Practice, and he confined his lectures to the latter. Policy, closely interwoven with finance, is primarily a matter for the Army Council, as I endeavoured to show in my earlier remarks; it is in the sphere of practice that the State looks to reap the full benefit of the technical skill of the Royal Engineers and of the individual economies which that skill may bring about. I need hardly say that by economy we do not mean economy of a cheese-paring kind, the economy of the jerry-builder. What we all aim at is the maximum of efficiency combined with the minimum of extravagance.

One—and only one—further remark on the Works subheads of the vote. The total estimate entered against any item represents only the estimated total of expenditure to be charged against the particular subhead, not the real total cost of the service. If land has to be bought, its cost is charged to the special subhead for the purchase of land, the incidental expenses being similarly charged, or to the Vote for Law Charges, which is not an Army Vote at all. Again, the cost of design, of drawings and bills of quantities, and of supervision is borne by other votes or subheads, for the most part in the shape of the pay and allowances of the persons employed thereon. Finally, any vocabulary stores that may be required are obtained free from the Ordnance Department without payment and any stocks of Engineer stores, not specially bought for the service, may similarly be freely drawn upon, while in many cases the cost of carriage and freight may fall on the Vote for Transport.

Although these charges do not appear against the Works item, it is

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obvious that they form part of the true cost and that this fact must never be lost sight of in discussing new services or in comparing costs generally.

To pass on now to the remaining subheads of Vote 10, we have next in order Subhead H, which provides nearly £11,000 for grants in aid of works carried out by other departments or bodies, in which the War Department may be interested. The special grants made to County and other Councils for the strengthening of roads and bridges, or as compensation for damage due to extraordinary military traffic, often present very great difficulties, into which, however, we need not enter here.

Subhead J provides £46,000 for purchases of land; and Subhead K £42,000 for the "rents payable" for lands and buildings, with the exception of buildings hired to supplement barracks.

Subhead L provides for Appropriations-in-Aid, that is to say for credits to the vote, estimated for the year in question to amount to £186,000; the principal anticipated receipts being £130,000 from the sale of lands, buildings, and materials, and £44,000 on account of "rents receivable" for lands and buildings belonging to the War Department. In every Army Vote there is a special subhead for Appropriations-in-Aid; the total of all these subheads amounting to nearly £3,500,000. Excess receipts are not available for increasing the gross expenditure.

There remains one further subhead, peculiar to Vote 10. This Subhead M provides for repayments under the Barracks and Military Works Acts. Under these acts money has been advanced on loan to the War Office for the purpose of carrying out large programmes, the loans being subsequently repaid by a series of annual payments, including principal and interest, spread over a definite number of years. The amount shown this year as payable to the National Debt Commissioners and to the Treasury is over £1,150,000. These Military Works Loans, sanctioned by special Acts of Parliament, form an exception to our national system of finance which, as I explained before, is based on the principle that the expenses of any one financial year must be met from the revenues of that year. In the case of extensive purchases of land or of large works services, the execution of which necessarily extends over several years, such loans present undoubted administrative advantages; but, as there is a tendency for services to be included in a Loan Programme without the same consideration that they receive when they have to run the gauntlet of the annual estimates, it has been found that loans do not always make for economy; and the policy of loans for Military and Naval Works Services has been abandoned by the present Government.

I propose now to revert for a moment to the consideration of the certificates required on the bills for Works Services before they can

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be passed for payment. I will only deal with one form of bill—the most important of all, on Army Form P. 1901. It is the Final Bill for a Works Service, and on it are entered all the measurements in detail. Now the primary authority for payment is the certificate of the Division Officer that the work has been satisfactorily executed, that the measurements are correct, and that the charges are in strict accord with the schedule of prices embodied in the contract. The bill is then passed to the Commanding Royal Engineer for technical examination and for him to certify that funds are available out of his allotment to meet the charge and to state the vote, subhead, and item, against which the charge should be made, before the bill is passed to the paymaster for payment. It is the duty of the latter to check the correctness of the bill as far as he can before paying; but, as the checking of measurements and schedule items requires technical qualifications, the full responsibility for the accuracy of Engineer bills in this respect has been assigned to the Royal Engineer officers in charge of the services. It is a responsibility which should not be lightly undertaken, as it is on the Division Officer's certificate that the whole system of accounting is based.

The fundamental necessity is that the measurements should be correctly taken; and it is now more than ever important that officers should be fully acquainted with the art of taking measurements. It has always been one of their duties; but until recently there was a staff of surveyors who relieved them to a considerable extent of this duty. Surveyors as such have, however, ceased to exist for Engineer Works; as Inspectors of Works they have to all intents and purposes become Division Officers. In the circular notifying the change it was clearly laid down that "Division Officers, both R.E. and Inspectors of Works, will be responsible for the complete execution of their services in every respect including designing (if not done by higher authority), estimating, and measuring up."

In the multitude of their duties officers may be forced on occasions to leave part to their subordinates. In such a predicament they will naturally reserve for their personal attention the matters which appear to them to be of the highest importance. They must not forget, at such a time, that from an accounting point of view, the taking or checking of measurements is of paramount importance. Their Foreman of Works may be, and generally is, a hardworking and trustworthy person, but it is not fair either to him or to themselves or to the State to leave to him the responsibility which rests with them. The rates and schedule items in a bill may all be correct; and the certificates signed without misgiving in the apparent absence of even the slightest ground for suspicion; but if the initial measurements are wrong, the whole superstructure is worthless.

The number of certificates on Engineer bills has recently been reduced, the reduction being accompanied by a stipulation that the

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remaining certificates shall not be signed by anyone under the rank of commissioned officer. My excuse for this lengthy digression is that in the bills that have recently come before me I have noticed a tendency on the part of the officer signing to avail himself somewhat readily of the proviso, intended for exceptional use only, that he may when necessary sign the certificate with the endorsement that the measurements have not been taken or checked by himself. If he cannot be present when they are taken, he should make every endeavour to check them.

A word or two in regard to the financial aspect of the various methods of execution of Works Services may be expected. Officers can either execute a service personally by the direct employment of military or civil labour, or can employ a contractor to do the work, either by measurement or under a contract for a lump sum.

The direct employment of civilian labour has latterly been more common than it was some years ago; the main difficulty that it involves, from my point of view, is that of securing an adequate check. A daily check is made by the Foreman of Works, and it is on that that the weekly wages bill, which Division Officers have to certify, is based. I fear, however, that in the past the latter have not had any adequate means of checking the foreman; and without such a check the system cannot be held to be entirely satisfactory, regarded merely as a system of accounting. The difficulty is not peculiar to the Army; but the commercial builder has his Profit and Loss Account to show him whether the work is progressing satisfactorily. It has always seemed to me desirable that, as is commonly done in the building world outside, and as, I understand, is the practice both at Chatham and at Aldershot, every workman should personally keep a weekly time sheet, showing for each day the hours worked and the particular work on which he is employed. These records must enable officers, by occasionally calling for and scrutinizing them, to exercise a better check than it is possible for them to do where no such records exist. Moreover, if every now and then they abstract the time taken by certain workmen over certain jobs, they will be in a position to compare their cost with contract prices; and such comparisons will assist them to determine whether or not their day labour is being economically administered. I was glad to see, in last month's Army Orders, that this system of time sheets, already in vogue at Chatham, has been officially recognized and made of general application in all commands where civilian day labour is employed.

The normal procedure, however, in the execution of an important Works Service is to employ a contractor. Measurement contracts have many attractions, as they do away with the necessity for the preparation of full drawings and bills of quantities. Embodied in such a contract is a schedule of prices for different materials and

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operations, and the contractor undertakes to execute any kind of work specified in the schedule at the prices named or at a fixed general percentage on or off these prices. This is an excellent system for jobbing work, that is to say for repairs, renewals, and small new services; and we have therefore at most stations a running measurement contract for all services the estimated cost of which individually falls within a certain limit. At present that limit is fixed at £400, but it is proposed to reduce it to £300, except at certain stations, where the volume of work is sufficiently large to justify a special higher limit of £500. These contracts for artificers' work run for periods of three years, and for this reason are generally known as Triennial Contracts.

For new services of any magnitude Measurement Contracts are apt to prove expensive, and financial considerations require that they should only be resorted to in cases of extreme urgency or in which there is no other alternative. Lump sum contracts should be the rule.

In regard to contracts in general, more especially for the purchase of stores, I should like to say a few words both on the system and on its application. In any large business concern there are two possible systems of buying; the purchaser may have recourse to competitive tendering to definite specifications, a system which gives him the benefit of low prices, but necessitates the maintenance of an adequate staff for inspection to ensure that the goods supplied are in each case in accordance with the specification; or he may employ special expert buyers and dispense to a great extent, if not altogether, with specifications and inspection.

In the case of the Army, where we are spending the public money without any Profit and Loss Account to show the result of our various transactions, special buyers would always be open to the suspicion of partiality, if not of corruption; and would prove extremely costly, in view of the great number and variety of articles required. We therefore adopt the alternative system of open or limited competition, and, as is done in most large businesses, employ a central buyer distinct from, but the agent of, the requisitioning departments. We have at the War Office a permanent official, the Director of Contracts, whose duty it is to make contracts for any articles or services demanded by the military departments, to specifications drawn by them, and subject to their inspection. Not only does this centralization lead to economy; but it also ensures continuity of policy and uniformity in the treatment of contractors and of labour questions. It is for this reason that Works Contracts, although of a different nature to contracts for stores, are included in the duties of the Director of Contracts.

The Contract Department is the nearest approach we have to a business department in the commercial sense; but if we wish con-

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tractors of the better class to deal with us, it is important that we should only imitate business methods in so far as they are above suspicion. It is therefore the duty of the Director of Contracts to be responsible for the general conditions of all Army Contracts and for the procedure to be adopted in calling for tenders and in the placing and subsequent administration of contracts, whether the contracts are made at the War Office or locally in commands. The regulations governing this procedure are detailed in character and of a stringent nature. A first impression of them may be that they are too rigid, and that they imply some distrust in officers; but it will soon be realized that this insistence on correct method of procedure is of the utmost importance, not only in the interests of the State, but in the interests of the officers themselves. For, like the man who deals in horses, the man who touches contracts is, in the opinion of a great part of mankind, immediately suspect. Disappointed contractors are at times reckless in their insinuations; and in order that there may be no difficulty in rebutting them, it is necessary that the chain of procedure should be formally correct in every link and such as can be publicly explained and justified without the possibility of the honesty of any single individual being called in question.

At home stations tenders for Triennial Contracts and for special Works Services estimated to cost £2,000 or more are invited locally, but accepted at the War Office. For smaller services at home and for all services abroad the acceptances are made locally, subject to an *ex post facto* review of the proceedings by the Director of Contracts. In any case it is important to remember that the contract is between the Secretary of State for War and the contractor; and the Commanding Royal Engineer, whose duty it is to see to its faithful execution on both sides, cannot alter its conditions in any way without reference to the War Office through the General Officer in Charge of Administration. It should always be borne in mind that the contractor, as well as the War Department, has his legal rights, and that considerate treatment may facilitate the satisfactory execution of the work and by encouraging firms to tender increase competition and thereby lead to economy. The conditions of contract are, perhaps unavoidably, somewhat stringent; hence the special need for equity and consistency in their enforcement.

I should like before concluding to submit a few remarks on Store Accounting in general and Engineer Storekeeping in particular. As in the case of cash expenditure, so also in the case of stores detailed and accurate accounts are indispensable. "Put all in writing that thou givest out or receivest in." That maxim is more than 2,000 years old; yet even in this present day it is extraordinary how many people there are, both in and out of trade, who are insensible to the importance of accurate book-keeping. In all store accounting the transactions must be

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supported by proper vouchers for both receipts and issues. If goods are purchased for delivery to store, a certificate of receipt must be given on the bill before it is passed for payment; if they are received from another store there must be a receipt voucher corresponding to the issue voucher supporting the account of the issuing store. It is the auditor's duty, by comparing store accounts with cash accounts and with other store accounts, to see that the goods bought or transferred are correctly brought on, or it may be written off, charge. There is not much difficulty in the case of Ordnance Stores, which are for the most part wholesale stores; in their case transactions are in bulk, and the issues are normally made to other wholesale stores or to retail stores under the Army Service Corps or the Royal Engineers, to whom the responsibility for retail issues is thus transferred. Retail issues are generally made for consumption; they must be supported by the signed requisition of the officer or other official duly authorized to make such requisitions. This is the case with both Barrack Expense Stores and Royal Engineer Stores. The issues from the former are, however, generally based on scales laid down in regulations; and the consumption can therefore readily be checked. But in the case of consumable Engineer Stores any definite scale of issue cannot be prescribed, and there is consequently no efficient check on consumption, beyond the general check of the Division Officer or the Officer in Charge of Stores. In matters of detail we have, as in so many other instances, to rely on the honesty of the Foreman of Works, on whose authority the issues are made.

It is admitted on all sides that Engineer Storekeeping has not in the past been satisfactory; but it is admitted at the same time that such failure as there has been has, for the most part, been due to inadequacy of staff and to a faulty system. Both these defects have now been remedied, by the appointment of Quartermasters as Officers in Charge of Stores with a special staff of ledger-keepers and store clerks, and by the introduction, now being made, of a new system, under which the discrepancies, so frequent and considerable in the past, should tend to disappear.

It is one of the first principles of a sound system of store accounting that the ledger-keepers should be entirely independent of the storeholders, and that the latter, who should keep their own records on tallies, should be forbidden all access to the ledgers. Disregard of this principle paves the way for dishonesty and the "cooking" of accounts; and it is in the disregard of this principle that one of the main faults of the old system of Engineer Storekeeping lay. I need hardly point out that, whatever the system may be, efficiency of storekeeping and accuracy of store accounting can best be secured by careful and continual stocktaking.

Finance and Accounts cover a wide field. The survey which I have attempted has embraced but a small portion of that field; and

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space has restricted me to considerations of a more or less general nature. Those who desire details, will find a plethora of them in the book entitled *Regulations for Engineer Services*. The size of the book, though it has been reduced, may still be forbidding, for we are all agreed that regulations are irksome and the multiplication thereof an evil; but it is justified by the responsible authorities at the War Office on the ground that the book is not strictly confined to regulations, but is more in the nature of a manual. A new and completely revised edition, so badly needed, has at last made its appearance; and I may, in conclusion, recommend it to special study as the book wherein is set forth the whole duty of man—at any rate within the sphere of Finance—if he happens to be a member of the Works Branch of the Corps of Royal Engineers.

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CEMENT IN THE TROPICS.

By Capt. K. E. Edgeworth, R.E.

Introduction.

The use of Portland cement in the construction of buildings has largely increased in recent years both in England and in America, and fresh opportunities for its employment are constantly being brought to notice. Although the ordinary uses and treatment of Portland cement are matters of common knowledge, there are certain properties of the material less widely known, which attain importance in tropical countries, and it is with these special peculiarities that it is proposed to deal in the present notes.

In discussing the setting of Portland cement there are two distinct stages which may conveniently be referred to as "setting" and "hardening" respectively. "Setting" is the initial change from a soft or plastic mortar to a friable solid. It is usually effected with great suddenness and is accompanied by the evolution of heat. "Hardening," with its accompanying increase of strength, continues for months or even years, and is due to a different set of chemical changes, although the exact nature of the reactions taking place is imperfectly understood.

The first six subjects which it is proposed to discuss are matters which affect the amount of cement used. In England cement is so cheap that economy of cement is usually of less importance than facility of construction. Abroad however the cost of cement may be much higher than it is at home, and the question of economy of cement may become of paramount importance.

Selection of a Suitable Cement.

The British Standard Specification ensures a material which will give fairly uniform results when used at home, but it by no means follows that the same cements will be equally reliable when used in the tropics. The effect of temperature in increasing the rapidity of set will be discussed below, but increase of temperature does not affect all cements equally. Certain cements are slow setting at 20° C. and quick setting at 30° C. This can only be ascertained by testing the cement at the higher temperature, and it is desirable therefore that the tests specified should be carried out as nearly as possible at the temperatures at which the cement will probably be used. It will always be found that manufacturers are willing to meet customers requirements by producing special cements for special purposes.

Even more important than temperature, however, is the effect of storage. Cements containing free lime are improved by storage,

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since the hydration of the free lime increases the soundness. On the other hand cements containing a high proportion of alumina, particularly if underburnt, become quick setting by the absorption of water and carbon dioxide. A typical example is given by Messrs. Reibling and Salinger. The cement contained 8·5 per cent. alumina and certain samples were collected in cans while others were collected in paper bags. After eleven days the samples were tested. Those from the cans showing 2·63 per cent. loss on ignition (H_2O and CO_2) set in 1 hour and 30 minutes, while those from the bags showing 3·92 per cent. loss on ignition set in 23 minutes. Such a cement is obviously quite unsuitable for use in countries where it is liable to long storage and exposure.

No method of overcoming this difficulty has been definitely accepted by engineers, but two points appear to be of primary importance. Firstly the cement should be low in alumina, the best results being obtained if the alumina is less than one third the silica. Secondly underburnt cement is particularly to be avoided.

The importance of proper packing should also be emphasized. It is not sufficient to exclude water from the cement, but as far as possible air should be excluded also.

It may be well to include a warning against "slag-cement" and similar materials which are manufactured in considerable quantities on the Continent. They resemble Portland cement in many ways, but are much less reliable, and should be used with great caution.

Many interesting points arise in connection with the testing of cement, but they are not suitable for abstracting and a reference should be made to larger works on the subject.

FINENESS OF GRINDING.

It has long been recognized that Portland cement depends for its activity upon the fineness of the grinding, and that it is only the very fine and impalpable powder which constitutes the active material. In ordinary commercial cement, it is probable that this active material is less than 40 per cent. of the whole, and there is therefore abundant opportunity for increasing the activity by finer grinding. For use in England it is found that, beyond a certain point, the increased strength is not a compensation for the increased cost of additional grinding, but it is obvious that different conditions may lead to different results and that the value of the finer cement will increase in direct proportion to the cost of transport. When cement has to be brought a long distance, it is worth while to consider whether it would not be cheaper to employ a lesser quantity of finely ground cement at an increased price per ton, instead of the usual commercial article.

A good example of the advantages of fine grinding is furnished by the material known as "sand-cement." This is produced by mixing the ordinary Portland cement with two or three parts of sand and then regrinding it. The resulting material can be mixed with a fresh

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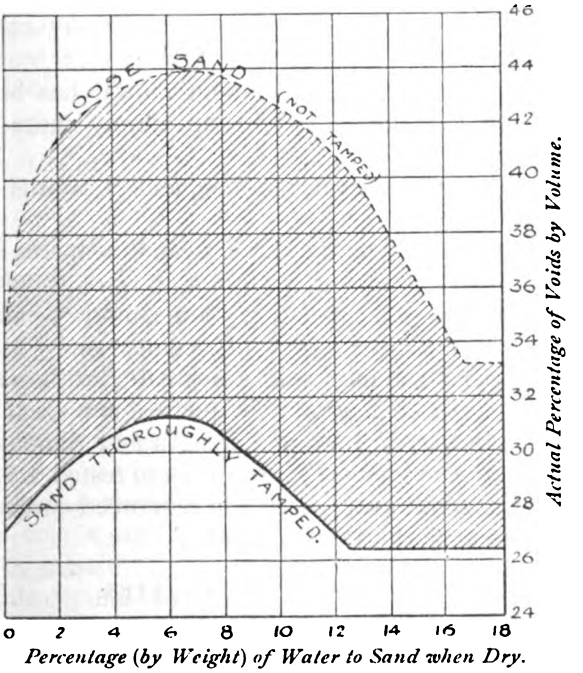
portion of sand, and will give results not much inferior to the original cement. Thus 1 part of cement may be mixed with 2 parts of sand to produce 3 parts of "sand-cement." The 3 parts of "sand-cement" may then be remixed with 6 parts of sand, and the resulting mortar will have approximately the same strength as a 1 : 3 mortar with the original cement. It might be expedient in certain cases to import cement and convert it locally into "sand-cement," thus effecting a considerable economy in the cost of transport.

Water used in Mixing.

The amount of water used in mixing a concrete affects the strength in various ways. In the first place an excess of water retards the setting and gives lower strengths especially for short periods. In the second place an excess of water is liable to wash away the grains of cement leaving portions of the concrete without any cement at all. In the third place the quantity of water used affects the density of the concrete when placed in position.

This last effect is well illustrated by some experiments of Mr. Fuller's on sand. He took a natural sand and measured the voids with different proportions of moisture. The results are shown in the diagram reproduced below.



Percentage of Absolute Voids in a Natural Bank Sand containing Varying Percentages of Moisture.
(From "*Concrete, Plain and Reinforced.*" *Taylor & Thompson*).

There is no doubt that the effect is due to the surface tension of the water. When the grains of sand are covered with a film of water, the

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surface tension will cause the grains to adhere together. This will increase the friction between the grains, and will prevent the sand from being consolidated to the same extent either by gravity or by ramming as the case may be. It is evident that the effect will reach a maximum when each grain is just covered by a thin film of water, and that it will decrease if the water is either in defect or in excess. It being impracticable to place concrete dry, the surface tension can only be avoided by using more water than is necessary to wet the surface of the grains, that is to say by using a plastic mortar. Small grains will obviously require more water than larger ones as they have a larger surface per unit volume.

Probably the ideal concrete in practice is obtained when the water will *just* flush to the surface when the mixture is fully rammed. Varying conditions will lead to corresponding variations in the amount of water which is required to produce the best result. Thus concrete blocks which are to be removed at once from the mould require to be rather dry, as an excess of water makes them lose shape and stick to the mould. Up to this point the more water they get the better. On the other hand reinforced concrete is used rather wet, as it must be free from hollows and the presence of the reinforcement prevents proper ramming.

Addition of Lime.

The effect of lime on Portland cement mortar has been discussed recently in the *R.E. Journal*, and I shall merely quote the principal results.

(i.). A mortar of ·85 cement, ·15 lime, and 3 sand is as strong as 1 cement, 3 sand.

(ii.). A mortar of ·6 cement, ·4 lime, 5 sand compares favourably as regards strength with 1 cement, 5 sand.

(iii.). A mortar of ·85 cement, ·15 lime, and 5 sand is almost impervious to water while a mortar of 1 cement and 5 sand is not.

The advantages of adding lime are greater with weak mortars. The writer has found that tension briquettes composed of 1 cement, 1 lime, and 12 sand, have the same strength as 1 cement and 8 sand. The briquettes were set under water but were tested dry.

Lime should not, however, be used in reinforced concrete as it may contain substances injurious to the steel.

Sands and Aggregates.

That coarse sand is better than fine sand for making mortars is generally recognized, but the true reason is not so well known.

Suppose a number of spheres of radius r resting against a flat surface, the arrangement of the spheres being hexagonal. The distance from the centre of each sphere to the surface is r.

If a fresh layer of spheres be added the distance between the two layers will not be $2r$ but $2r\sqrt{2}\sqrt{3}=1{\cdot}63r$, and so on for other layers.

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That is to say that the layer in actual contact with the surface will have a greater proportion of voids than the bulk of the grains which will take up the arrangement known as "normal piling."

It is well known that sand grains, though not perfectly spherical nor uniform in size, can assume an arrangement giving a maximum density and corresponding to the "normal piling" of uniform spheres. When sand grains adjoin a surface they will also exhibit a similar increase in the normal proportion of voids, or to put the matter more simply, the layer nearest the surface will be less dense than the remainder.

When two sets of grains of different diameters are mixed together the finer grains will not be able to adjust themselves perfectly to the voids in the larger. Even when the difference in size is great, there will still be a "surface effect" due to the causes described above. A calculation on the assumption of uniform spheres shows that the effect is still appreciable when the finer grains are one-fiftieth the diameter of the larger. Since a considerable number of cement grains will exceed $\frac{1}{500}$" in diameter we should expect to find that the strongest mortars could only be obtained with sand grains measuring $\frac{1}{10}$" and over, a result which agrees well with experience.

Coarse sand alone, however, is only suitable for very strong mortars such as those containing 1 cement : 2 sand, and for weaker mortars the introduction of some fine sand is desirable.

A French authority, M. Feret, took three sands :—

A very coarse sand	·20" to ·08"
A medium sand	·08" to ·02"
A fine sand	less than ·02"

He mixed these sands in every possible proportion, and used the mixtures in mortars composed of 1 cement and 3 sand. He found

(i.). That a sand composed of 4 parts very coarse sand with 1 part fine sand gave the best possible mortar of 1 cement 3 sand.

(ii.). That the strength of such a mortar is more than twice as much a 1 : 3 mortar made with ordinary coarse (*i.e.* medium) sand, and more than three times as strong as mortar made with fine sand only.

It is necessary to observe, however, that the advantages of very coarse sand are less marked when used in concrete than when tested alone, as the coarse sand does not accommodate itself so readily to voids in the aggregate.

M. Feret also found that for other proportions than 1 : 3 the most advantageous mixture was obtained when the weight of coarse sand is equal to twice the combined weight of fine sand and cement. This result is of particular importance for the weaker mortars and concretes. A mortar containing the proper proportion of fine sand may be 50 per cent. stronger than a mortar in which fine sand is entirely absent, or in the alternative a mortar of equal strength can be obtained with about 30 per cent. less cement.

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The proportioning of sand to aggregate is usually done by measuring the voids in the latter, and this method is sufficiently accurate when the aggregate consists of fairly large uniform pieces such as broken stone. Better results can be obtained however when the aggregate and sand together contain material which is uniformly graded from the largest to the smallest.

The question has been very fully examined by Mr. Fuller, an American investigator, who has devised a method of grading the aggregate by means of sieve analysis curves. He found that, with an ordinary gravel divided into two grades, the proportions required for a waterproof concrete were about $1 : 2\frac{1}{2} : 4\frac{1}{2}$. Using the same gravel but separating it into five grades instead of two, he found that a water-tight concrete was obtainable with a mixture of 1 : 3 : 7, thus effecting a saving in the quantity of cement used of more than 26 per cent.

Regarding as aggregate all particles greater than one-sixth the maximum, his ideal curve shows that the aggregate should be to the combined sand and cement in the proportion of three to two. The aggregate should in itself be uniformly graded, that is to say one-half should be more than the mean diameter and one-half should be less than the mean diameter. Mr. Fuller's curve for the sand gives mixtures not very different to M. Feret's as regards fine sand, but it recommends coarse and medium sands in about equal proportions instead of coarse sand only. The discrepancy is probably due to the fact that the former experiments refer to concretes whereas the latter were made on mortars only. It is noticeable that the proper proportioning of fine sand is of more importance than all the rest put together. The following is an example of a concrete proportioned according to the above rules :—

2 cement.
2 fine sand (under ·02″).
4 medium sand (·02″ to ·08″).
4 coarse sand (·08″ to ·25″).
9 small aggregate (·25″ to ·87″).
9 large aggregate (·87″ to 1·50″).

For stronger mixtures cement can be substituted for the fine sand and *vice versâ*.

It is not always necessary to separate all the above constituents. Sometimes a mixture of three grades will fulfil the above rules with sufficient accuracy for practical purposes.

Use of Minimum Quantity of Cement which Work Actually Requires.

Strength is not the only property which has to be taken into account in deciding the proportion of cement to be used in any particular job. In Europe a porous concrete would be liable to

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disintegrate under the action of frost, or an impermeable concrete may be required for other reasons.

For the construction of dwelling houses in tropical countries there is no need to use an impermeable concrete, and the only considerations are those of strength and convenience of manufacture. Owing to the great cost of forms when concrete is used in mass, the most usual method of construction is by means of concrete blocks which are allowed to set before being built into the work.

The blocks are usually made with a comparatively dry concrete, and are immediately removed from the mould on carrier plates. After one or two days they are tipped off the plates and covered with damp sand until sufficiently hard for building with. The present writer has found that blocks can be successfully manufactured with a mixture of 1 : 8 : 16 (by weight), if the blocks are allowed to remain two days on the carrier plates. With care in handling the breakages should not exceed 5 per cent. In this case 90 per cent. of the sand passed a sieve with 30 meshes to the linear inch, and the sand must therefore be classed as fine. With a mixture of fine and coarse sands in the proper proportion there should be no difficulty in making blocks with a mixture of 1 : 12 : 24. The crushing strength of such a mixture should be about 700 lbs. per square inch at the end of three months. This is considerably more than is required for single storey buildings, and it may in fact be stated generally that, for single storey buildings, the block will be more severely tried during manufacture and erection than it can afterwards be in the building itself. By setting blocks under glass in the sun, the writer has actually used a mixture containing half the proportion of cement stated above, but the cost of cement was about £12 per ton and the circumstances must be regarded as exceptional.

Time of Setting and Hardening.

The rapidity of setting increases to a remarkable extent with increase of temperature as will appear from the following table (due to Bauschinger) :—

Temperature. °C.	Initial Set. Hours.	Final Set. Hours.
0	21	38
5	9	20
10	5	13
15	3¼	10
20	2	7½
25	1½	6¼
30	1	5
35	¾	4¼
40	½	3½
45	¼	3
50	0	2½

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This property of cement has several important practical applications which are enumerated below.

(i.). The British Standard Specification states that the cement must be tested between certain temperatures. If this is not possible then an allowance would have to be made for the conditions under which the test is actually carried out. The increased rapidity with which cement sets in hot climates has occasionally been a source of misunderstanding between purchasers abroad and manufacturers at home.

(ii.). In hot climates the materials for the day's use should not be exposed to the sun, and water should be used as cold as possible.

(iii.). Only slow-setting cements should be specified for ordinary work.

(iv.). Cement mortar or concrete should only be mixed in such quantities as are required for immediate use, as they may deteriorate perceptibly in a couple of hours.

(v.). The accelerated set may be taken advantage of in various ways. For example concrete blocks may be set under glass frames in the sun. There is also a process for manufacturing blocks or tiles from wet concrete which is poured into a mould containing a steam jacket. The block dries sufficiently in a few minutes to enable it to be removed from the mould and no doubt the partial setting of the concrete plays an important part.

The increased rate of hardening (as distinct from setting) with increasing temperature depends greatly on the quality of the cement, as certain ingredients may adversely affect the strength at high temperatures. This falling off in strength is less noticeable with Portland cements than with the natural cements which are largely used in America, but it should always be allowed for in blocks prepared by any of these processes.

As an example of what can be done, the writer has found that tension briquettes composed of 1 cement $7\frac{1}{2}$ sand, placed under a double glass in the sun in Cairo during the summer time, attain a strength in three days which they would take about three weeks to acquire under ordinary circumstances.

CHANGE OF VOLUME IN SETTING AND HARDENING.

In the absence of impurities there is no appreciable change of volume during the setting of cement.

During hardening, cement expands in water and contracts in air.

Hardened in air, neat cement shrinks almost uniformly for the first three months, the linear shrinkage in that time being from ·12 to ·34 per cent. Mortar composed of 1 cement and 1 sand shrinks from ·08 to ·17 per cent. in the same time. Further information is needed, but the writer suggests that the ultimate value of the shrinkage is not less than the higher of the two figures given above, and that the contraction of weaker mortars is in proportion to the amount of

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cement, *i.e.*, the final contraction of a 1 : 6 mortar would be about ·03 per cent. or 1 in 3,300.

When cement concrete is used, or when masonry or brickwork is built in cement mortar, the contraction will depend on the nature of the aggregate. The more rigid the aggregate the less will the contraction of the cement affect the masonry as a whole. A good example of the truth of this principle recently came to the writer's notice. Some new barracks in Egypt were constructed with "sand-lime" bricks in 1 : 6 cement mortar, the roofs being of steel joists filled in with concrete. The modulus of elasticity of the "sand-lime" brick is less than half that of the cement mortar, and in consequence the cement mortar exerted a predominating influence on the final result. The buildings cracked right across, floors, walls, and roofs being equally affected. The average distance between the main cracks was about 60′. The enclosure walls showed the same trouble with even greater regularity, the cracks appearing throughout the entire wall at intervals of 20′ or 30′. Walls built on the same site and with the same bricks, but in lime mortar, were comparatively free from cracks. Sometimes the cracks made their appearance when the wall was only a few courses high.

Although the trouble was due in the main to the use of cement mortar, it may be well to add that the "sand-lime" brick itself may have contributed to the trouble, as experiments have since shown that it expands about 1 part in 5,000 when immersed in water, and contracts again on drying.

In addition to large cracks affecting the whole building, vertical cracks are nearly always traceable in concrete buildings underneath the windows. According to the circumstances of the case they may vary in width from a mere hair crack to $\frac{1}{8}$″ or even larger.

There are three methods of avoiding cracks in cement buildings, or at all events of reducing them to a negligible amount.

The first method is to introduce horizontal reinforcement. Unless a very large amount is used the reinforcement will not prevent the cracks entirely, but it will diminish their importance by causing them to appear at more frequent intervals. Theory indicates that the larger the amount of reinforcement and the smaller the rods composing it, the closer together will be the cracks and the less in consequence will be their individual importance.

Reinforcement amounting to $\frac{1}{3}$ per cent. will be found to meet ordinary requirements.

The second method of preventing cracks is to introduce contraction joints at suitable intervals. The distance between the joints will vary from 5′ or 6′, in the case of pavements, to about 70′ in the case of sewers and culverts. In American practice they are usually placed 50′ or 60′ apart in ordinary buildings. These contraction joints, however, are not usually sufficient to prevent the smaller cracks which appear where the masonry is weakened by window openings. To

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avoid these it is desirable to introduce a little reinforcement both into the sills and lintels.

The third method of preventing cracks is only applicable to buildings constructed of concrete blocks. It consists in allowing the blocks to harden before building into the work for a sufficient period to enable the contraction to reach its full amount. Owing to the thinness of the joints and the rigidity of the blocks themselves, the contraction of the mortar is insufficient to affect the masonry as a whole.

The writer is not acquainted with any publication which gives the period after which contraction ceases, and the following results based on personal observation of actual buildings are put forward with all due reserve. He finds that buildings are free from contraction cracks if the blocks are set for twelve months, and that, if the blocks are set for three months, the cracks will not be of sufficient magnitude to attract attention unless specially looked for.

In any case it is well to avoid weakening the masonry more than can be helped in the arrangement of the openings. For example, reinforced lintels should be used instead of arches, and ventilation openings should be placed, not immediately above doors and windows, but in the intervals between them.

REINFORCED CONCRETE.

In all important construction the resistance of reinforced concrete is increased by the introduction of stirrups or similar devices to take the shearing stresses, but it is not usual to employ them except on work of some magnitude. The writer has observed cases in which horizontal cracks have made their appearance in reinforced concrete lintels. As failure did not occur it is obvious that the cracks were not due to overloading, and in fact the loads were far within the capacity of the beams.

The trouble is doubtless due to the contraction of the upper layers of the concrete in hardening. The contraction of the lower layers being prevented by the reinforcement, there is a tendency for the upper and lower halves of the concrete to separate.

In very dry climates therefore it would appear to be undesirable to omit the reinforcement against shearing, even in cases where the strength of the beam appears sufficient without it.

DAMP-PROOF COURSE.

Bitumen sheeting shows excessive softening in hot climates, and the action is more marked with concrete walls on account of their thinness. Trouble arises in two ways.

Firstly, the compression of the sheeting is seldom uniform, and cracks may develop in the masonry owing to unequal settlement.

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Secondly, the bitumen sheeting acts as a lubricant and forms a plane of weakness on which the wall can slide. The writer has seen the centre of a long wall bulging outwards the ends being held in place by cross-walls. The actual movement was about an inch, and the wall was subsequently pushed back about half this amount and retained in place by buttresses. The unequal expansion of the wall due to the sun shining on the outside is the only force which can be suggested capable of producing the movement.

The remedy is to avoid bitumen sheeting if possible. There are many cases in which a damp-proof course can be dispensed with. For example, when building with concrete blocks on a dry, sandy, or gravelly soil, a course of solid blocks to separate the hollows in the walls from those in the foundations will usually be sufficient. Asphalte appears to give less trouble than bitumen sheeting if a damp course of some sort is required.

Concrete Roofs.

For roofs, concrete is generally employed in combination with iron either in the form of girders or reinforcement. Roofs composed of these materials possess not only great weight but also great rigidity, and their expansion and contraction are a frequent cause of trouble.

The expansion taking place in a direction parallel to the supporting walls presents no great difficulty. If the roof is constructed of steel girders filled in with concrete, the girders themselves form joints at which the necessary movement can take place. In reinforced roofs expansion joints can be left at convenient intervals.

The expansion taking place at right angles to the supporting walls however cannot be dealt with entirely by this method, as the span itself must remain intact. A description of two actual cases will give the best idea of the class of trouble which is to be anticipated.

Case I.—The buildings are ordinary barrack blocks and accessories with spans varying from 15 to 18′. The method of construction is shown below.

In the summer following the completion of the barracks it was found that large horizontal cracks had appeared at A and that the parapet walls were being bodily pushed outwards. Sometimes slight cracks were also noticeable at B.

The following precautions suggest themselves as a means of avoiding similar trouble :—

(i.). Lime concrete should be used in preference to cement as a protection for the bitumen sheeting on flat roofs.

(ii.). If cement concrete must be used, a space should be left between the concrete and the parapet wall, and should be filled with asphalte or some other elastic material.

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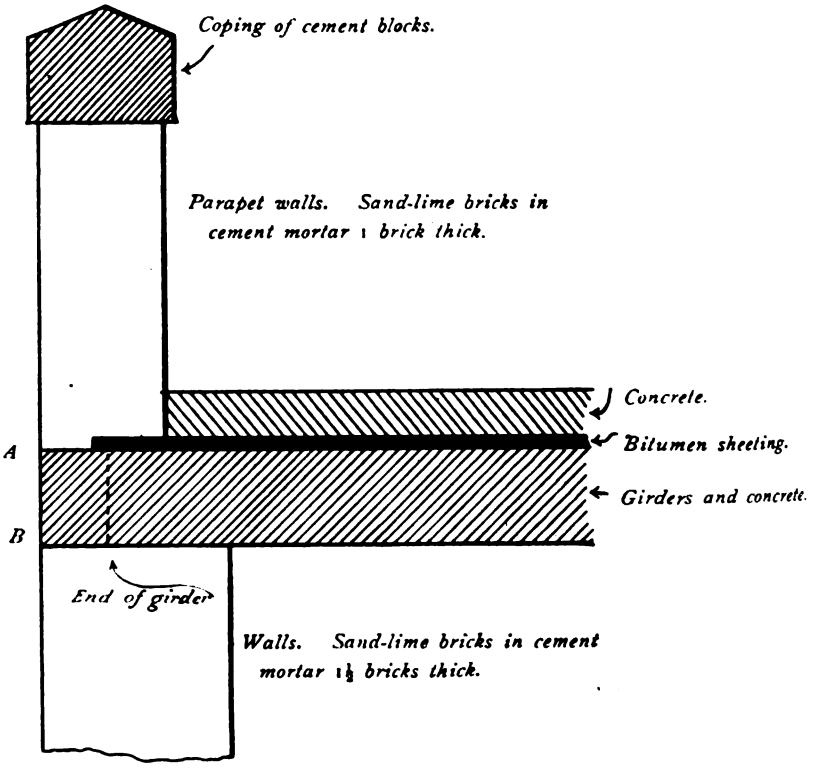
(iii.). The bitumen sheeting should not be carried straight through the parapet wall. It should first be carried a short distance vertically upwards and then tucked in.

(iv.). If the outer surface of the wall is plastered, the concrete of the roof should be carried outwards to form a cornice. Any small cracks that may appear will not then disfigure the building.



Case II.—A large engine room, span about 40'. Roof of reinforced concrete of the usual type with slab and T beams in one piece. No bitumen sheeting or other covering above the concrete.

The roof caused such extensive and repeated cracks in the walls that the owners were compelled to erect a galvanized iron pitch roof over the reinforced concrete in order to keep off the sun. The trouble then ceased.

This case is principally of interest as showing that expansion troubles are accentuated in large roofs. The actual remedy applied is somewhat crude, and a few inches of lime concrete would probably have been equally effective and would certainly have been more elegant. The trouble could of course have been avoided by the introduction of suitable expansion joints in the walls and roof when the building was first constructed.

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Effect of Drying.

Some interesting experiments were made by Mr. Lucas at the suggestion of Major Tucker. A number of ordinary tension briquettes were made of neat cement. Some were tested wet, while others were allowed to dry for varying periods in air. The results were as follows :—

	Tensile Strength lbs. per sq. in.	Decrease Per Cent.
7, 8, 8½ and 9 days in water, mean	463	—
7 days in water + ½ day in air	315	32
7 „ „ 1 „	281	39
7 „ „ 1½ „	248	46
28, 29½, 30 and 30½ days in water, mean ...	596	—
28 days in water + ½ day in air	373	37
28 „ „ 1 „	320	46
28 „ „ 1½ „	236	61

Briquettes 7 days in water ½, 1, and 1½ days in air, replaced in water for ½ day and then tested gave a mean of 499 lbs. per square inch. Briquettes 28 days in water, ½, 1, and 1½ days in air, replaced in water for 1 day and then tested gave 541 lbs. per square inch.

Similar experiments on mortar of 1 cement, 3 sand did not show any decrease of strength on drying.

As experiments are still in progress it would be premature to offer possible explanations of this somewhat remarkable result.

Effect of Exposure to the Sun.

The usual method of hardening concrete blocks is to place them in piles and spray them from time to time with water. The writer undertook some experiments to ascertain whether exposure to the sun when the block was green was likely to prove detrimental.

The experiments were made in Cairo during the months of June and July. Tensile briquettes $1\frac{1}{2}'' \times 1\frac{1}{2}''$ of the usual shape were employed. Half the briquettes of any batch were left in a damp room for 24 hours and were then placed in water. The other half were placed outside. Being made in the evening they would usually be exposed to the sun within about 15 hours of their manufacture. After three days' exposure these blocks were also placed in water. The whole batch was tested after a period of three or four weeks. "Dry" mortars were removed from the mould at once and "plastic" mortars after 12 hours. The different batches are not comparable as they were made at different times with different cements.

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The results were as follows :—

Proportion by Weight.			Treatment.	Time of Setting.	Tensile Strength on 2¼ Square Inches.					Mean.	Effect of Exposure to Sun.
Cement.	Sand.	Water.									
1	7	·45	Under cover	21 days	240	240	250	230	220	236	+ 11%
			Expd. to sun		230	270	240	260	310	262	
1	5	·4	Under cover	21 days	270	280	250	—	—	266	+ 14%
			Expd. to sun		320	290	300	—	—	303	
1	3	·3	Under cover	21 days	345	320	350	—	—	338	− 1%
			Expd. to sun		280	395	330	—	—	335	
1	3	·4 *	Under cover	28 days	570	560	600	—	—	577	− 16%
			Expd. to sun		420	560	480	—	—	487	
1	3	·45 *	Under cover	28 days	500	535	535	—	—	523	− 5%
			Expd. to sun		530	475	475	—	—	493	
1	2	·3	Under cover	28 days	640	640	—	—	—	640	− 16%
			Expd. to sun		480	600	—	—	—	540	

The mixtures marked * were plastic. The other mixtures were dry enough to admit of being immediately removed from the mould.

The general result is that the strong dense mixtures are adversely affected by the sun, while the weak porous mixtures receive no harm. Too much reliance must not of course be placed on results obtained from such a small number of specimens, and in any case different results might be obtained with other materials. In particular the amount of water used exerts an important influence.

CONCLUSION.

A list of references is given below. Extracts have been freely made from all the works named and the writer takes this opportunity of acknowledging his indebtedness. Thanks are also due to Colonel Davidson, R.E., and Major Tucker, of the Barrack Construction Department for permission to use apparatus and for advice and encouragement, and to Sergt.-Major Button, R.E., for help and advice with the actual tests.

One word may be added in conclusion. These notes are intended to arouse interest in the various points mentioned rather than to act as a guide on such an extensive subject. Those in charge of important works will naturally consult the original treatises for fuller information. It must always be remembered however that the materials used are of infinite variety, and that no amount of knowledge derived from books will take the place of that gained by experiment in the laboratory or observation of actual buildings.

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Major-General William Edmund Warrand, R.E. (Bengal), J.P., D.L.

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MEMOIR.

MAJOR-GENERAL WILLIAM EDMUND WARRAND, R.E. (BENGAL), J.P., D.L.

THE late Major-General William Edmund Warrand, R.E. (Bengal), J.P., D.L., Notts and Inverness; Alderman of the Notts County Council; F.G.S., F.B.A.A., was born on the 2nd January, 1831, at Westhorpe Hall, Southwell, Notts, the home for generations of his ancestors, and dating back to the reign of Henry VII. The Warrand family have produced many distinguished soldiers, and General Warrand was the son of the late Major Robert Warrand of the Inniskilling Dragoons who was wounded in the Mahratta War. His father, grandfather, and great-uncle before him saw active service, and his maternal great-uncle, General Jekell, married Lady Griselda Stanhope, who was a niece of Pitt.

Given a cadetship by Sir James Hogg, Bart., M.P., at the request of the Earl of Lincoln, Warrand entered the Honourable East India Company's Military College at Addiscombe in February, 1848, where his contemporaries were the late Lieut. Leverton Donaldson, killed in action near Rangoon in 1852; the late General William West Goodfellow, C.B., Colonel Commandant, R.E. (Bombay); the late General Sir George Chesney, K.C.B., C.S.I., C.I.E., Colonel Commandant, R.E. (Bengal); and the late Major-General William Spottiswoode Trevor, V.C., R.E. (Bengal). After passing through Addiscombe he was appointed 2nd Lieutenant in the Bengal Engineers on the 9th June, 1849, and having completed the usual course at Chatham he went out to India, and arrived in Calcutta in May, 1851. He was then ordered to do duty with the headquarters of the Bengal Sappers and Miners at Loodianah. In May, 1855, he was appointed to officiate in charge of the 3rd Division, Department of Public Works, and after passing the language examination he was placed in charge of the Western Sirhind Division in April, 1857.

On the outbreak of the Indian Mutiny, Lieut. Warrand was ordered to Ferozepore and aided in repelling an attack by the mutineers on the Ferozepore Arsenal which was the largest in Upper India. Had it fallen into the hands of the rebels, Delhi could not have been captured without considerable delay, as the besieging force depended mainly upon Ferozepore for the supply of the munition of war. The native garrison consisting of one cavalry and two infantry regiments, a battery of field artillery and a company of foot artillery, broke out on the 13th May. The mutineers forced their way inside

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the fort but were fortunately checked by the wall which surrounded the arsenal, and this obstacle, insignificant as it was, enabled the guard to hold its own. Originally this guard consisted entirely of native soldiers, but after the outbreak at Meerut, Europeans had been told off for this important post; so strong, however, here, as elsewhere, was the belief in the loyalty of the sepoys that the native guard was not withdrawn. This same guard when the attack took place, did its best to assist the assailants and even prepared scaling ladders to enable the latter to gain access to the magazine enclosure. The Europeans however were equal to the emergency; they overpowered and disarmed their treacherous companions, and then succeeded in beating off and dispersing the attacking party. Being foiled in this attempt, the mutineers returned to the cantonment, set fire to the church and other buildings, and then started for Delhi.*

From Ferozepore Warrand was ordered to Delhi and was appointed Field Engineer to the Delhi Field Force from the 29th July, 1857.

It may not be out of place here to give some idea of the difficult task in which he was now called to take a part.

During the early part of the siege the Delhi Field Force was engaged in repelling the enemy's sorties. There were usually three or four sorties in each week, and some of these were on a very large scale. Large bodies of the rebels could be seen issuing from the Lahore Gate, cavalry, artillery and infantry. The general plan of the sorties was to turn our right flank by a large force and to penetrate into our camp, while smaller numbers advanced under cover of the rocks and bushes for a direct attack on the ridge. In crossing the road leading from the Lahore Gate to the Subsi Mundee the cavalry and artillery came under the view of our right battery which poured a heavy fire into the enemy's troops. Those that escaped this ordeal swerved to the left, and returned in a disorganized state, by the Kabul Gate, or some of the other gates. The enemy also made frequent night attacks on our position, and a continual roll of musketry would be kept up for hours. There was a small post among the rocks on the right of the ridge called the Sammy House which was obstinately held by our men throughout the siege, and the writer of this Memoir remembers seeing the corpses of the mutineers after one of their attacks, piled up among the rocks and sweltering in the sun, there being no men available to bury them.

The ground around Delhi which was traversed by many canals and roads was, at the time of the siege, a tangled mass of old ruins, dense woodland, rice fields and swamps of notorious insalubrity. It offered innumerable facilities for occupation by armed men of any degree of

* The above account of the mutiny at Ferozepore is related in *Forty-One Years in India*, by Field Marshal Lord Roberts.

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discipline, and indeed so incompatible were its features with the action of a mass of disciplined troops, that the many combats of which it was the scene were rather trials of skill between small bodies than operation by masses.

So many fluctuations in the strength of the Delhi Field Force occurred at an early period of the siege that the precise numbers cannot be given, but from 500 to 600 sabres, from 2,500 to 3,000 bayonets, and 22 field guns may be taken as fairly representing the strength during the earlier operations. It is extremely difficult to form an accurate estimate of the strength of the enemy, but as some of the most important accessions which he received did not occur until the siege had been some time in progress, it may be inferred that on the 8th June the garrison of the place did not exceed about 8,000 or 9,000 disciplined soldiers, supported by about the same number of half-disciplined and wholly undisciplined but armed men.

For operations in the open field the sole strength of the garrison was in the trained soldiers, but for the operations in the rugged ground around Delhi, resolute men familiar with their weapons and profiting by the universal cover everywhere supplied in some house or other, were antagonists whom it was necessary to respect.

The garrison by the beginning of July must have consisted of not less than 15,000 to 18,000 trained soldiers, and irregulars in even larger numbers.

The besieging force numbered of all arms under 5,500 fighting men, Europeans and natives. An enterprising enemy might therefore with perfect ease, have maintained one or more strong movable columns, operating constantly on the communications, stopping convoys, harassing small detachments, disturbing the whole tract of country whence supplies were obtained, and finally in all human probability compelling the General in command to raise the siege from the impossibility of procuring subsistence for his army in a position so utterly insecure.

Instead however of obstinate and continuous operations of this class, the enemy was satisfied to make feeble efforts, never sustained for any considerable time, and easily warded off by corresponding movements of columns detached from the force. It was necessary however at the time under notice to take precautions against both forms of attack. The vast numerical superiority of the enemy converted the position of Sir Henry Barnard's force from the very first into that of a besieged, instead of a besieging army.

The attacks by the garrison on all points of the ground held outside the walls were incessant. The casualties of the force day by day were incessant. Many of its bravest and best officers had been killed or wounded; the daily average of casualties among the soldiers averaged from about 30 to 40 and on occasions of vigorous combats the loss rose from 100 to 150. It was scarcely possible to resist the convic-

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tion that the army was steadily and surely being used up by the ordinary process of the siege, and it seemed as though a simple calculation would show how long such a rate of waste of life could be sustained in presence of an enemy, by a force numerically so feeble; long it plainly could not be. To shorten the siege, or limit the waste of life, were the urgent necessities of the position.

The total casualties in the two actions of the 10th and 15th July having risen to nearly 500 men, it was necessary to abandon all idea of any active operations against the place from the latter date. Up to that time it had been the personal conviction of the Chief Engineer, duly submitted to the consideration of the General Commanding, that the possibilities of success by assault were such as would justify the attempt being made, should the political necessity for it be so great as to warrant very grave risks being accepted. It was no matter of regret to the Chief Engineer that his judgment on this point was never put to the test, it having been held that the risks were greater than the circumstances of the moment would warrant the General in meeting, but from this time his views were entirely in accordance with that conclusion and thenceforward but one idea regulated the operations of the Engineer Brigade, to prepare, namely, by economy of men and material on the spot, and by the collection of the same from every available point for the breaching of the city walls, and the attack of the place by siege operations, followed by open assault.

It may be remembered that the siege took place during the rainy season, so that the troops were continually drenched. The Engineer officers had to take parties of unarmed coolies out at dusk, and to work between the ridge and the city, their work usually consisting of felling trees and brushwood, and clearing the ground in front of the picquets. Attacked by the enemy in the darkness and rain it was really wonderful how patiently these poor coolies bore their sufferings, and their conduct was a matter of universal admiration. All the troops suffered alike. The officers received a daily tot or ration of rum like the men. The sales of effects of officers who had been killed took place almost daily, and articles of uniform or clothing were in great request. A bottle of beer sold for 4 or 5 rupees, and a bottle of brandy for 20 rupees.

The unarmed pioneers, about 600 in number, were brought down by Lieut. (now Lieut.-General) H. A. Brownlow and they were formed from volunteers taken from the workmen employed on the Ganges Canal. Strange to say, these men, who were at once transferred from the peaceful tasks of day labourers to the most dangerous duties of working parties in siege operations, never exhibited a symptom of fear, but worked under the hottest fire like veterans, and were invaluable. The casualties among them were inevitably very numerous, but no instance occurred of their having hesitated to obey any order, whatever its consequences might have been. Lieut. Brownlow brought

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with him, under their escort, a large supply of stores of various kinds for the Engineer Park, drawn from the workshops of the Canal Department.

Capt. (now General) Sir Alexander Taylor, G.C.B., had succeeded on several occasions in penetrating alone through the enemy's outposts, for the purpose of studying the ground, and on the general information so obtained and on his own knowledge of the locality the Chief Engineer, Colonel Baird Smith, prepared the project for the attack. On the evening of the 6th September the project was formally considered by General Wilson. General Nicholson volunteered to accompany Taylor to see the ground and the posts selected for the batteries. It was now dusk and they did not know the strength or disposition of the rebels. They went to some of the places of importance and found them unoccupied. Nicholson was satisfied, and reported what he had seen to General Wilson who then gave his sanction to the Chief Engineer's proposals. The project of attack submitted by the Chief Engineer to the Major-General Commanding and honoured with his sanction, provided for a concentrated rapid and vigorous attack on the front of the place included between the Water or Moree and Cashmere Bastions, provision being made at the same time, for silencing all important flanking fire whether of artillery or musketry that could be brought to bear on the lines of advance to be taken by the assaulting column.

Due care was also taken to protect the exposed right flank of the trenches from sorties. The left was secured by being rested on the river, and by the occupation of the Koodsiah Bagh, a very strong post in front.

The best information procurable indicated that on the front of attack the fire of some 25 to 30 pieces would have to be subdued. To effect this 54 siege guns were available.

The plan of attack consisted in principle in establishing on the front of the fortification selected, an artillery fire so much more powerful than that of the enemy on the same front, that the result must be to silence his guns and crush his works.

The Chief Engineer had good information that on the front between the river and the Cashmere Bastion not more than 30 heavy guns could be brought to bear upon our approaches, so arrangements were made for placing 56 pieces of siege ordnance, of various calibres against this front, and in about four days the whole opened fire with terrific effect. Two excellent breaches were made in the walls within 48 hours; the cover for the enemy's infantry was at the same time utterly swept away; an incessant storm of shot and shell poured into the place, and on the 14th September all was ready for the final assault, which was accordingly given with brilliant success.

Lieut. Warrand had been wounded on the 30th August by a fragment of a shell, and his arm had to be amputated. The writer of this Memoir saw him several times after he had been wounded,

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and he bore his sufferings and the amputation with the greatest fortitude and patience. The plague of flies was very great, the surgical appliances were scanty, and very few either of the officers or men who had to undergo amputation of the limbs survived the operation. General Warrand's splendid constitution and courage enabled him to pull through. His great regret was that he was prevented from taking part in the final siege operations, and in the assault of the place.

When sufficiently recovered from his wound Warrand was sent as a convalescent to Simla, among his fellow travellers during a portion of the journey being the son of the famous Dr. Arnold. He returned to England in 1858, and was received at his family seat at Westhorpe with great rejoicings. He was promoted to be 2nd Captain on the 27th August, 1858, and on the same day was gazetted to a Brevet Majority. At the close of the year 1860 Warrand returned to India as the head of the Civil Engineering College at Calcutta, and he was appointed Deputy Consulting Engineer in the Railway Department at Lahore in March, 1863, and in November, 1863, he was appointed to officiate as Assistant Secretary to the Government of the Punjab in the Railway Department.

After again seeing service with a small expedition against the frontier tribes he returned to England in 1867.

He was promoted to the rank of Regimental Major on the 5th July, 1872, and his other promotions were Brevet Lieut.-Colonel 14th June, 1869, Regimental Lieut.-Colonel 1st April, 1874, Brevet Colonel 1st October, 1877.

He was appointed Commanding Royal Engineer at Chatham and Belfast, and after further periods of service at Newcastle, Aldershot, and Inverness, he retired from the Army in August, 1883, with the honorary rank of Major-General.

General Warrand was always ready to place his military experience at the service of younger men in his profession. He took very great interest in the Nottinghamshire regiments of Volunteers, and, later, in the carrying out of Mr. Haldane's Territorial scheme. He was at once asked to join the Nottinghamshire Territorial Association on its formation, and deference was always paid to his opinions and advice.

In civil life General Warrand proved himself to be possessed of great administrative capacity, and he was actively associated with almost every public body of importance in the county. He had been a member of the Notts County Council since its formation in 1889, and was elected Alderman in 1909. At Southwell he took an active interest in all local matters. He was one of the oldest Guardians on the Southwell Board, and after the remodelling brought about by the Local Government Act of 1894, he was and had been continuously since, triennially co-opted on the Board. For years he was also a member of the Rural District Council and

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took a prominent share in the discussions on the Southwell drainage scheme.

General Warrand was a Justice of the Peace, and Deputy Lieutenant of Notts and Inverness, and was senior magistrate of the Southwell Petty Sessional Bench.

He was also a Governor of the Southwell Minster Grammar School where he had received the earlier part of his education.

In politics he was an ardent Conservative and convinced Tariff Reformer.

General Warrand was greatly interested in all matters connected with the science of natural history. He was a regular contributor of articles connected with this science to the *Royal Engineers Journal.* At his house at Westhorpe he had a large astronomical telescope.

In the domain of sport General Warrand was always prominent. He was the oldest member of the Rufford Hunt, and also a regular follower of the Earl of Harrington's and the Blankney. He began hunting nearly 70 years ago, and for keenness, cleverness, and courage had few equals in the field. In December, 1909, he met with a bad accident. He had been out with the Blankney, and at dusk was riding a spare pony homeward when it stumbled pitching the General heavily on his shoulder whereon was pinned the vacant sleeve of his coat. He picked himself up and remounted his pony intending to ride on to the Midland Station, where he intended to entrain for Southwell, but his friends persuaded him to accept a cab home and it was then found that his injuries included a broken collar-bone, which to a man of his years was very serious. Such however was his wonderful fortitude and pluck, that he soon pulled through and was about again.

General Warrand was a man of fine physique and his distinguished bearing marked him out for notice at any public gathering. It was it is believed his intention to hunt again this season and he had ordered his horses up for preparation.

In October last after attending a meeting in Nottingham, General Warrand contracted a chill, and he had since been confined to his room. At his advanced age of 79, notwithstanding his splendid constitution, the development of his indisposition was regarded almost from the first with alarm, and after some days' illness he passed away on the 22nd October, 1910. When King Edward inspected the Crimean and Indian Mutiny veterans paraded on the occasion of the visit of the Royal Agricultural Show at Derby in June, 1906, General Warrand took command of the Notts contingent and accompanied His Majesty when he walked down the ranks. On June 3rd, 1907, the 50th anniversary of the Siege of Delhi, together with 52 other officers, survivors of the siege, he was presented to King Edward by Lord Roberts at His Majesty's Levée.

General Warrand was thrice married, firstly to a daughter of the late Rev. H. Houson, of Brant Broughton, Lincolnshire; secondly

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to Mrs. Grant, of Bucht; and thirdly to Helena Anne, daughter of Perceval Maxwell, of Finnebrogue, Downpatrick. He is survived by his widow, one son, the Rev. Henry Kenneth Warrand, Rector of Bilsthorpe, Notts, and one daughter, married to B. Prescott-Westcar, Esq., of Strode Park, Herne.

Officiating at Southwell Cathedral on the Sunday after General Warrand's death the Rev. H. Gray at the conclusion of his sermon said "Major-General Warrand belonged to the sister parish of Holy Trinity, but he was ever a familiar figure in our midst, and was so closely associated with all true Southwell interests, that it was only right and fitting that mention should be made of him from this place. An old soldier, who had rendered good service to his country, he possessed the true characteristics of a soldier; fearless and downright, accustomed to rule, impatient of opposition, high-principled and manly, there was a breeziness and heartiness about him that we shall all miss. Admirable on the Bench, a man of strong political bias, he took a prominent part in local and national politics, and if a little bit out of sympathy with the democratic tendencies of our times, was yet in many ways a type of all that was best in the old-fashioned squire of a period that is rapidly passing away."

Before the ordinary business of the Notts County Council was commenced at the Shire Hall on October 25th reference was made to the death of General Warrand, who was for many years a member of the Council. Lord Belper said he thought he should be voicing not only his own opinion but the feeling of all members of the Council in referring to the great loss they had sustained during the past two days by the death of General Warrand. The General's career was well known. He was an active soldier and took a prominent and distinguished part in the Indian Mutiny, but what they regarded, as much as any distinguished services he might have rendered to his country, was what he did during his life in the county after he had retired from active service. As a magistrate he was attentive to his duties, and he took a great interest in the work of the County Council. In conclusion Lord Belper moved:. "That this Council wishes to put on record their sense of the loss the county has sustained by the death of General Warrand, and expresses its sympathy with Mrs. Warrand and her family in their bereavement." Viscount Galway seconded, and the resolution was unanimously carried.

The funeral took place at Holy Trinity Church, Southwell, on October 26th. A detachment from the South Notts Hussars, Territorial Yeomanry, composed of the Southwell Troop with the Permanent Staff from the Nottingham headquarters were present. There was also present a detachment from the 8th Notts and Derby Sherwood Foresters.

EDWARD T. THACKERAY.

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TRANSCRIPT.

OBSERVATION LAND MINES.

Extracts from an article, by L. DEBOGORII-MAKRIEVICH, in the January, February and March, 1910, numbers of the *Injenerni Jurnal.*

THE author of this article was in charge of the mine defences on the land front at Port Arthur, and in this article he gives some notes on the work done during the siege and deductions from the experience there gained.

The Charges.—It was found by experiment that double cases, made of millboard with a 1″ layer of waterproof composition between them, were ineffectual for keeping out the damp of even moderate rainy weather. Single cases of wood were as bad, but double cases of wood with a 1″ thickness of waterproof composition were effectual in damp ground.

In Port Arthur, where the mines were intended to remain in the ground for several months, three kinds of receptacle were found to be suitable:—

(1). Consisting of two wooden cases, as described above, made of 1″, or ¾″, planking, carefully fitted, with composition poured between them;

(2). Also two cases, one of which was of tin, with either an inner case of millboard or an outer one of wood, with composition between them; and

(3). Thick iron mine cases with their mouths hermetically sealed.

Fig. 1 (see *Plate*) shows a receptacle for a 20 lbs. charge of powder. It consists of two cases, the outer a kerosene oil tin, and the inner a cylinder of millboard, with a mixture of asphalt and pitch poured between them. The top of the inner case consists of two millboard covers, the inner round and the outer square, with sawdust between them. Above this is a layer of composition, and a tin lid is soldered on the top. The composition was made of asphalt and pitch or tar, mixed in the proportion of 2 to 3 parts of asphalt to 1 of pitch, with a little sand added to thicken it. When intended for tarring the outside of mine cases less sand was used. When used for filling the space between the double cases, the mixture was poured in hot, the inner case having been previously filled with stones.

Fig. 2 shows the author's arrangement for hermetically sealing the passage of the leads through the lid of the tin case. Charges made up in this way were connected in groups, at intervals of about 21′ apart, to form the first experimental obstacles laid in the bed of the river Lun-ho. Although they were left under water for some months they remained in good order, and some, laid in February, were exploded by lightning in

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May. They were never used against the enemy as he did not come into their neighbourhood.

Fig. 3 shows a case made of wood planking, to hold 2½ puds (90·27 lbs.) of powder. This was the type most generally used, and it was applied both to fougasses and to ordinary mines. The sections explain the construction of the cases. They were fitted with three lids, the inner one being pierced with a single hole for the leads, but no wide opening was left in it for pouring in the powder, as it was found that this was best done before the lid was put on. A layer of sawdust separated the inner from the middle lid, in which there were two holes for the leads. The space between the middle and outer lids, and also that between the inner and outer cases, were filled with composition, and the outer cases of all mines were always given an outside coating of composition.

The leads were cut in short lengths of about 7′, and were fastened to the inside of the receptacle by means of copper screws, and to the outside on metal clamps, this last being done to prevent the waterproofing from being broken when they were stretched.

These receptacles were made in three sizes, the interior dimensions of the inner cases being as follow:—

For a 1½ pud (54·16 lbs.)	charge of powder	...	12″ × 12″ × 12″.
,, 2½ ,, (90·27 lbs.)	,,	,,	...	14″ × 14″ × 14″.
,, 5 ,, (180 55 lbs.)	,,	,,	...	18″ × 18″ × 18″.

When filled they weighed 213·66 lbs., 266·88 lbs. and 435·54 lbs. respectively.

Charges prepared in this way were left in the ground for several months, but during the heavy rains there were a few cases of the powder becoming damaged by the damp. The chief faults of these cases were their size and weight, and the long time which they took to prepare.

Of the metal mine cases used, some were ordinary coast defence mines, and others were old Chinese iron cases captured in 1900. They did not possess the faults of the wooden cases. The tin-lined chests supplied with Chinese coarse-grained powder were also adapted for use as mine receptacles. Only those in the best state of preservation were selected, and these were carefully treated with composition, but they were not always waterproof, either from faulty construction or from the difficulty in closing their openings.

Size of Charge.—The effects to be expected of a mine explosion depend chiefly on the noise, the concussion of the gases and the air, and the vibration of the ground, and consequently the size of the charge need only be limited by the question of economy. Pyroxiline is preferable to powder. It is naturally unwise to use small charges with observation mines. There is a great deal of labour expended in preparing the firing station and carrying the leads under ground, and altogether it is very costly. In the case of mines laid near to one another, in a group, and the whole fired together, it is hardly worth while using charges of less than 90 lbs. of powder, and isolated charges should not be less than 300 lbs. The siting and combination of mines must depend on their

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object and upon the ground. Thus, is it better to use one charge of 900 lbs., or three of 300 lbs., or six of 150 lbs., or ten of 90 lbs.? The larger the charge, the more powerful is its action, but when we increase the number of charges we enlarge the sphere of their action, and we also render them less liable to the effect of the enemy's shells and counter-mines. The author is of opinion that groups are better than single charges, so long as each charge of a group has a considerable death-dealing sphere of action of its own.

The choice of the explosive used in a mine will be influenced by what kinds are available, their explosive force, and also by the question of smoke. Smoke may sometimes be of use and sometimes harmful. Thus, in driving off an attack the less smoke the better, while in covering a retirement or in case of a counter-attack, smoke may allow the defenders to retire or advance unnoticed. The tactical use of smoke on a battle-field is worthy of consideration. Belligerents should always have at hand the means of producing smoke over a large area and for a considerable period of time, and at a greater or lesser distance from themselves.

The Limitations of Land Mines.—Experience confirmed the common opinion that land mines can be used with success in supplementing the artillery and rifle fire of the defence.

Their advantages are as follows:—

1. Supposing that a hostile column passes over the mined area, then careful timing of the explosion is more easy to the miner than is accuracy of aim to the rifleman or gunner.

2. The explosion of a mine, besides causing actual loss to the hostile column and bringing it to a standstill, always produces panic. This moment of panic must be seized upon for bringing a heavy fire on the disorganized troops, and for the counter-attack.

3. Mines may be laid in dead areas which are safe from the rifle and artillery fire of the defence.

4. Mines laid for the defence of some work or battery may be fired from a neighbouring trench even after the work has fallen, and may thereby cause an alarm which will greatly assist the counter-attack.

Their disadvantages are:—

1. Fixity of site, which can only be remedied by their liberal distribution.

2. The mine acts only once. Time and suitable conditions are necessary for the preparation of a fresh one. This may to some extent be remedied by laying spare mines, in the same or in a second line, or even underneath the original ones. Care must be taken that the spare mines are not fired by the concussion caused by the explosion of the others. The disconnecting boxes, described later, for protection against lightning, may be usefully adapted for rapidly connecting up the spare mines, or better still some automatic system may be devised for connecting them up after the explosion of the others.

3. If the position of a mine is discovered by the enemy, its value is more than half gone. The same remark applies to a mine relaid in a site known to the enemy. Before attacking he will take care to demolish it or to cut off its connection.

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Tactical Siting of Land Mines.—Under this heading the following points require to be considered:—

1. Distance from the firing line of the defence.
2. Direction of action of the explosions.
3. Mutual siting of isolated mines, and of groups.
4. Siting of charges in relation to the plans of defensive works and trenches, obstacles, and points most liable to attack.
5. Inequalities of the ground, open and dead areas.
6. General bearing of the minefield, whether along the lines of probable attack, or across them.

The distance of the mines from the defensive trenches may be limited by questions of materials, men, time, circumstances, objectives, or by the nearness of the enemy. It is unwise to make hard-and-fast rules which may trammel the initiative of those who are laying the mines, and who must study the ground, the local conditions and the requirements of the defending riflemen. The following limits and influencing factors may be mentioned:—

(*a*). The distance should not be less than 30 paces. If less, the explosion might damage the defenders or the mines might be exploded by shells aimed at the trenches, whereas the enemy should at least be obliged to expend special shells for the demolition of the mines. When a mine is exploded the defenders must pay no attention to the shower of earth and stones, but must keep up a heavy fire without waiting even for the smoke to clear off.

(*b*). The distance should not be so great that it is difficult for the defenders to see accurately when the enemy passes over the charge.

(*c*). The physical and moral effects are greatest when the mines are near the trenches—physical because the effect will be better the better the observer can see his work, and moral because the strain on the nerves of the attackers increases as they approach nearer to the works of the defenders.

(*d*). The value of all obstacles depends on their protection from damage, and the nearer the mines are to the defenders the more easy will it be for the latter to defend them.

(*e*). The value of a land mine is greatly increased by the rifle and artillery fire which can be brought on those of the enemy who are panic-stricken by its explosion. Therefore in open ground they should be sited within the sphere of accurate rifle fire of the defence, *i.e.* within 400 paces. But they may have to be put further off.

When placed in dead ground they tend to assist the rifle defence by driving the enemy into the open, where they can be shot down, and in this case the nearer they are to the trenches the more successful is their action, for they will then frighten his supporting columns from taking cover in such dead ground. In Port Arthur it was only possible to lay a limited number of mines and these were placed in the nearest dead areas, with the effect that after a few successful explosions they compelled the enemy to make use of open ground for their advances.

It may therefore be taken as a rule that it is *desirable* to site mines

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within the sphere of effective rifle fire, but it is *necessary* to have them within the sphere of protection and observation.

As regards the direction of action of a mine, this may be either (i.) vertically upwards, (ii.) inclined towards the enemy and perpendicular to the line of defence, (iii.) inclined towards the enemy and at an acute angle to the line of defence, or (iv.) from above downwards, in which case only stones thrown by the explosion, and not the explosion itself, will act upon the enemy.

Case (i.) is suitable to isolated mines in open ground where the enemy may be caught in masses. Care must be taken that the explosion will not injure the defenders.

Cases (ii.) and (iii.) are suitable to fougasses and ordinary mines on sloping ground. These are more effective than vertical mines, especially in the case of fougasses which cover a large area with their stones and shields. (ii.) is suitable when owing to local conditions the attacking columns may be expected to be deep and on a narrow front, and when there are many mines placed at narrow intervals, while (iii.) is suitable for opposing widely extended lines with mines placed at wider intervals. Or the direction of explosion may depend upon local conditions, as when the mines are spread like a fan round a salient of the defence, or when they are intended to enfilade a tract of dead ground lying along the front of a position.

Case (iv.) is suitable when it is desired to use a fougasse like a gun to sweep some ravine or particular area, or where leads are not long enough to reach the whole distance. Several cases occurred at Port Arthur of applying this method, principally when the enemy did not pass exactly over certain mines, and there appeared to be a probability of the latter being wasted. The effect of the stones alone is not nearly so great as that of the explosion, which of course is the really effective item of a land mine. Best of all is the combined effect of explosion and stones, which effects all parts of the attacking column.

In considering the least and greatest intervals at which mines, or groups of mines, may be placed one from another, the former are influenced by the size of the charges, the nature of the soil and the shape of the ground. The explosion of one charge must not be allowed to injure its neighbours, and for this reason the minimum interval between two mines may be taken to be that at which their areas of effective action *above* ground, due to concussion, etc., and, in the case of fougasses, to the stones also, meet.

Charges fired simultaneously, forming a group, may be placed at shorter intervals than isolated charges and groups, unless the charges of two or more groups are intermingled, in the intervals between one another, on one piece of ground (see *Fig.* 4).

The maximum intervals must depend on circumstances, and vary in different parts of the position. They may be influenced by the probable width of the attacking columns, due to the restrictions of the ground, or by the means and time at the disposal of the defenders. It is generally advisable to site charges as near to one another as allowable, and to economize by placing them only in the more important sections of the

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position. The ground and the general scheme of other defences will never allow symmetry in the arranging of land mines.

The siting of charges, or lines of charges, in the depth of a position, as regards minima distances, is subject to the considerations already given. The placing of many lines of mines may lead to a dangerous amount of smoke, or may cause too much confidence in their effectiveness, which may lead to disappointment if they become damaged by hostile fire and fail to act.

Generally speaking, in addition to considerations of means, time, labour, circumstances, and to the plans of the other defences, the number of lines of mines depends upon the following conditions:—

1. The necessity of having all within the range of effective rifle fire.
2. The shape of the ground.
3. The siting of other obstacles.
4. The need of free ground for counter-attack.
5. The desire of not allowing the enemy to come too near.
6. The desire of not having large clouds of smoke too near the defenders.
7. The risk of over-confidence and possible failure.
8. The tactical importance of the section of defence.
9. The possibility of several attacks being made on the one section.
10. To some extent, on the strength or weakness of the other works at any point.
11. If the defenders are much shaken, the enemy must not be allowed to come within 200 paces, and the mines must be placed proportionally further to the front.

Mines placed one below another, with a view to destroying men who run for shelter in the craters of those first exploded, involve a great amount of work and make large craters. They were not tried at Port Arthur and the writer has no experience of them.

Turning now to the siting of mines with regard to other works, they may be placed in front of the strong points, or in the intervals between them. In the case of some advanced works which are liable to capture, the parapets themselves may be mined, or egress from them may be obstructed by mines in rear and to the sides. Villages liable to capture may be similarly treated. At Port Arthur the mines were at first laid in the intervals between works, but when the direction of an attack was revealed some of the engineers insisted on mining the nearer approaches to the forts themselves. The difficulty of protecting the leads from bombardment when there is no time to dig deep trenches for them, must be taken into consideration. A device of Engineer Yakovlev is mentioned, by which the mines are laid in pipes.

As it will seldom be possible to lay mines continuously along the front of a position, they should generally be massed (i.) in sections liable to attack but otherwise weakly defended; (ii.) in sections where active defence is contemplated as the panic caused by their explosion forms a useful prelude to a counter-attack; and (iii.) where there is dead ground near the position which cannot be otherwise covered.

As regards the siting of mines with relation to other (passive)

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obstacles, this must depend on the siting of the latter, on the object of the mines and on the shape of the ground.

As the passive obstacles must be within effective range of the rifles, they will generally be placed between 10 and 200 paces in front of them, while mines can be placed from 30 to 600 paces. For this reason the mines cannot always be sited within the passive obstacle, though the advantage gained by causing a panic among the enemy, after he has passed the latter, is obvious. Mines and leads are also easily damaged, and require frequent examination and repair, and this is an additional reason for placing them within the passive obstacle. If the leads can be buried deeply and the outposts of the defence are far enough to the front to allow of the mines being examined if necessary, then the desire to secure a better target may justify the siting of mines further to the front.

Some people advocate the siting of mines at the passive obstacle itself where they may catch the attacking troops checked and crowded.

In the case of dead ground the choice of sites for the mines will in no way depend on the siting of other obstacles.

At Arthur the mines were generally laid in dead ground or in areas badly covered by rifle fire. This was due to the fact that the positions abounded in such places, and the scarcity of materials did not allow in addition the mining of open ground at the probable points of attack. The result noticed by the miners was that the Japanese came to avoid dead ground and preferred to advance over the open, where they were exposed to shell and rifle fire. Those mines, therefore, which were never fired, had a certain indirect value. The difficulty of finding observation posts for mines sited in dead ground had often to be got over by watching the approaches to the dead areas only. In the case of mines so laid, it was not often possible to take full advantage of them by bringing a heavy fire upon the disordered enemy.

A large quantity of smoke thrown up by the explosion of a mine may be useful to the defenders by concealing them and blinding the attackers. But with mines laid in the open smoke will generally interfere with the rifle fire on the disordered enemy, and in such cases it is better to use a smokeless explosive.

Details of Construction.—With *ordinary mines* the charge should be as near the surface as possible, in order to obtain the full effect of the charge and to reduce the size of the crater. If one considers, separately, the necessities of concealment, protection from weather, from rifle bullets, shells, saps and countermines, various results are arrived at, but a mean of between 2′ and 4′ of earth above the top of the mine may be taken as what would be generally suitable. The excavation may be perpendicular or inclined to the surface of the ground, and should fit the size of the charge receptacle as accurately as possible. The mine should be carefully tamped and skilfully masked.

The *fougasses* used at Port Arthur were of a special type, (see *Fig.* 5), which may be described as follows :—

The chamber for the stones was square in section, and so cut into the hillside that its end wall, which stood at right angles to the floor, was

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about 4′ square, and its top about 1′ below the surface. The floor was splayed outwards, and was about 7′ wide at the outside. The charge chamber was excavated in the middle, or slightly below the middle, of the end wall. On the floor of the stone chamber were laid two planks, abutting on the end wall and splayed slightly outwards. On these the shield, which measured 3½′ square, and will be described separately, was placed standing against the end wall. The planks and floor were covered with a 3″ layer of sand, which was intended to allow the shield and stones to slide freely in the sticky clay of the excavation, and a 6″ layer of sand was also filled in on the sides and against the shield, during the laying of the stones. No stones of smaller size than a man's head were used, and the bigger ones were placed in the centre of the mass, near the shield. The stones were covered up with earth, and the whole carefully disguised. A party of four men could bring up the charge, excavate the chambers, and lay one of these fougasses by night in four to six hours.

The size of the shields (see *Fig.* 6) was decided by the weight which four men could conveniently carry. They were made of three or four layers of 2½″ or 3″ planking, the planks of each layer being firmly fastened together by nails driven diagonally through the joints, before the layers were nailed one to the other. Shields made in this way having been found to break up by the explosion, they were afterwards strengthened by being bound together with four bands of hoop iron, two in each direction. These shields if carefully made did not break up with a 90 lbs. charge of powder.

The *trenches for the leads* can be arranged in any of four ways:—

1. With one "magistral" line, and branches from it to the charges.
2. With a separate trench running to each charge.
3. With a separate trench for each lead, *i.e.* two to four to each charge.
4. With trenches arranged to suit the ground.

The first type has the fault that all the mines can be put out of action by one shell. The second is safer, but gives more work, and if care is not taken in the aligning, when several leads get near the firing station, they will become as vulnerable as in the former case. The third is safer still but gives still more work. There is not the same necessity for separating the trenches near the mines, as the enemy can hardly be expected to expend shells in trying to discover the latter. This system is only suited to mines laid very close to the firing station. The fourth method, that of laying the leads on reverse slopes, in ravines, or on ground which is unlikely to be swept by hostile artillery fire, entails largely increased earthwork and leads, but is especially suited to rapid laying, where the leads have to be left unburied. *Figs.* 10, 11 and 12 explain the three first systems of arranging the leads to separate charges or groups. With armoured cables the armouring was very often used instead of a return wire, but earth was never used for this purpose.

The *masking* of the trenches was arranged either by carefully disguising the filled-up trench itself, or by turning up the whole surface of the ground, or by laying the lines in places defiladed from the enemy's view. Rain spoils the masking, as it makes the newly filled-in earth sink, leaving noticeable hollows, which must be quickly filled up.

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Care must be taken, when filling in trenches, to lay shallow layers and to ram them well, but it is not permissible to leave a mound along the line of the trench.

In spite of the risk of their being cut, it is not wise to lay the leads too deeply, as this adds to the labour of repairs. At Port Arthur during the provisional period they were laid 2½′ to 4′ deep according to the soil, and during the siege from 6″ to a foot. When they became more untrustworthy they had to be laid in the open.

There were also occasions during the siege when mine galleries were used for the leads of ordinary fougasses, but the method of using boreholes for the leads was not used, owing to the want of tools suitable for boring the stony ground.

The *firing stations* were stoutly-built field casemates, measuring about 10′ × 7′, or 9′ × 9′, and sunk about 7′ in the ground. They were roofed with three layers of beams, and above these iron sheets or straw mats, and 5′ to 7′ of earth. The doors were made of 3″ planks, and were reached either by ladders or from communication trenches. Each casemate contained a guard bed, cupboard for food, etc., clothes pegs, arm-stand, stove, etc. If the casemate was too small for living in, another was made alongside for this purpose.

In choosing the site of a firing station the following conditions had to be satisfied :—That it was protected by rifle trenches either in front or in a line with it; that it was near a good observing post, from which all the mines connected with it, or the approaches to them, could be seen; and that it was protected from artillery fire. It was therefore preferably placed on high ground on a reverse slope, and not too near any work or battery which was liable to bombardment. If possible, the observers should be so close that their voices can be heard in the firing station. Telephones are unsatisfactory as their wires are easily cut, and it is not easy to use them during the noises of a battle; they are however suitable for work at night. If any mines could not be seen from the observation posts it became the custom to inform the neighbouring riflemen of their siting, and to trust to them to give information of the enemy's approach to them. A small rifle position should always be prepared near the observation post, from which the miners can themselves protect their station, and join in the fight if necessary. A supply of electrical and other tools was kept in each station, and also journals for registering tests and recording events. To each sector of the defence there was assigned an electrician on duty daily, for carrying out tests in the stations of that sector.

The *testing and firing tables*, fitted in the stations in the precautionary period, were arranged as shown in *Fig.* 7. They measured about 2′ × 3′, and 2½′ high. At the right end the firing keys were connected to the positive leads from the various mines, while the return leads were connected together and brought as a single line to the switchboard at the left end. A three-way switch connected up the firing or the testing circuit at will.

The keys were numbered to correspond with the numbers of the mines,

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the latter being shown on a plan which hung on the wall of the casemate. The table had an oilcloth cover to keep off the dust.

As the siege progressed and the arrangements became less elaborate, keyboards, hanging from the walls, were used. *Fig.* 8 shows one with firing keys, and *Fig.* 9 one with a wandering lead. The latter arrangement has the advantage of eliminating the possibility of mistakes, and can also be applied to a firing table.

The *firing apparatus* was either an exploder, a battery of Le Clanché cells, or an accumulator. The exploders are best, as they require little looking after, and the batteries are the most troublesome. Accumulators require means of charging them and men who understand them.

Mines may also be laid in the open and fired by our own artillery fire, or they may be fired by time fuze.

Of the various *leads* used during the siege the Government armoured ones were the best. They were less affected than others by the explosion of hostile shells and were not easily cut by hand.

Towards the end of May and the beginning of June several charges were exploded by *lightning*, and General Stessel ordered that means must be taken to protect the mines from such accidents. No special apparatus, such as that used with telegraphs, was available, and it was necessary to improvise. A former authority had suggested that such explosions are caused by currents set up in the leads at the points where they are brought out of the ground, but on the night of the 1st—2nd June, 18 charges, connecting up into two groups, but with the ends of their wires insulated and buried, and disconnected from the leads by a gap of 8′, which had been laid in rear of one of the Russian works were exploded in this way. The only remedy seemed to be to disconnect the leads close to each charge, and, with the object of doing this rapidly, the writer designed a disconnecting box (see *Fig.* 13) which would be buried a few inches deep near each charge, and contained two wandering leads, which could at will be connected with clips leading to the charges, or rapidly transferred to insulated recesses. In this way if the men could approach the charges they could connect or disconnect the latter in a very short space of time. But this could not of course be done from within the firing station, and some design which would render it possible to do this is greatly necessary.

In selecting sites for mine obstacles the writer was generally guided by the necessity of protecting the intervals between forts, and the ground in front of weak sections. It was desirable that the mines should (i.) aid in repulsing assaults and compel the enemy to a regular siege, (ii.) cover dead ground near the rifle positions, (iii.) bring actual loss on the enemy, (iv.) discourage the attack and encourage the defence, (v.) temporarily, at any rate, arrest the progress of surprise attacks, (vi.) compel the enemy to avoid cover which they might believe to be mined, and (vii.) compensate for the temporary removal of the defenders of a particular section in case of urgent necessity. But they cannot be expected unaided to repulse an assault, they are only subsidiary aids to the vigour and courage of the defenders, who must not be too greatly discouraged if they fail to act.

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The *personnel* attached to each firing station—desired, if rarely attained, even at the beginning of the siege—consisted of an electrician as chief of the station, an assistant, and three reliefs of scouts, single or in pairs, for one or two points. Later on, when the scouting was almost entirely handed over to the riflemen, they were content to have one man on duty, day and night, at each station, watching the front-lying ground.

The following difficulties were encountered in the work : —

1. There was a great deficiency in the supply of well-insulated leads, of which there were only some 15 to 20 versts, when the total length required exceeded 100 versts, and even telephone cables had to be used. 2. The inferiority of the leads greatly hampered the scheme of mine defence. 3. The scarcity of money and labour compelled economy in trench work. 4. The Chinamen employed disclosed to the Japanese the positions of mines and cables. 5. The depths of 2½′ to 3′ in stony ground, and 4′ in clay, though sufficient to protect mines and leads from the projectiles of field artillery, were useless against those of siege artillery, whose craters were often 7′ deep. 6. The concealment of the cable trenches was often very imperfect. 7. There was no service mining equipment and everything had to be improvised. 8. The mining detachments were made up of riflemen, sappers, gunners, railway men and others. 9. The improvised cases sometimes allowed the powder to get damp. 10. The mining defences of a fortress like Port Arthur is a large business, and experience showed that theoretical knowledge on the subject requires considerable development.

There were also the following personal difficulties :—

1. There were insufficient officers, and their duties had to be largely done by N.C.O.'s. 2. Constant interruptions to the circuits led to much exhausting and dangerous night work. 3. Casualties among the *personnel* were either filled by men quite ignorant of the work and of the minefields, or were not filled at all. 4. As the leads got worse the difficulties increased. 5. While the work kept on increasing the men were getting weaker. 6. After the writer himself was wounded in the head, in mid-October, he was not so capable of pressing on the work *everywhere*. 7. In October three assistant officers were wounded, and there remained only an ensign to assist him in the administration of the laboratory and 15 stations, between Battery Letter A and the Lun-ho, working day and night, and constantly fighting. 8. The mines could not be properly observed, so that if the enemy came upon them in their saps, they sometimes cut the leads, and connected the ends together, with a view to leaving the Russians to suppose that the mines were still in working order.

Reports on the fighting during the defence hardly did justice to the effect of the observation mines, as the mining detachments themselves were generally reticent, and others were naturally inclined to attribute successes to their own efforts. But it says a good deal for the success of the mines that those commanding in the firing line were always asking for more mines, and up to the last day of the siege had not lost faith in them. All ranks in the neighbourhood of the firing stations were asked to notice and report on the effect of the mines as far as possible, but

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observing was very dangerous work and the smoke thrown up by a mine moves quickly away and is soon lost sight of amid the smoke of bursting shells. The only reports obtainable were from the firing line which contained few officers and were not often very reliable. In some cases the writer has found in foreign journals reports which coincided with and confirmed his own impressions.

Experience showed that it is a very good achievement if one can succeed in firing 30 per cent. of the mines over which the enemy passes. As he may only be estimated to pass over some 10 to 20 per cent. of all the mines laid on a position, it results that only 3 to 6 per cent. of all the mines will ever act upon the enemy. If the leads suffer much, the proportion may fall as low as 1 per cent.

F. E. G. SKEY.

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NOTICES OF MAGAZINES.

NEUE MILITÄRISCHE BLÄTTER.

23rd September, 1910.

THE NEW EQUIPMENT OF THE BRIDGING TRAIN OF THE GERMAN ARMY.—The Bridging Trains of the German Army are allotted as follows:—

(*a*). As divisional troops.

(*b*). As corps or army troops.

Hitherto the equipment of both divisional and army troop trains has been the same, the only difference between the units lying in the lesser number of wagons of the former.

The main disadvantages of the old form of pontoon were:—

(1). It was found to be no longer large enough to form bridges capable of carrying such recent innovations as traction engines, other forms of mechanical transport, and heavy field artillery.

(2). When used as a single pontoon it was too unstable.

(3). Its weight deprived it of mobility, as men could not be carried on the wagons when they were obliged to move on at a trot to hurriedly get to the site of a new bridge.

The desideratum was thus, on the one hand, a pontoon capable of carrying greater weights, and *ipso facto* a heavier one; on the other, a lighter and more mobile boat. In consequence of the conflicting nature of these desiderata it was decided to abandon the idea of having but one type of pontoon, and to adopt two quite different patterns of equipment; the lighter for the divisional, the heavier for the army troop bridging trains.

To take the latter first, its length is 8 metres, breadth 1½ metres and freeboard ·85 metres; its bottom is sloped up towards the front, which is raised ·25 metres above the rest of the bulwarks; the stern is rounded off; its weight, 5,000 kilos., is only 100 kilos. greater than that of the old pontoon, but its supporting power is about 2,000 kilos. greater than that of the old pattern. Other differences are:—

(1). The baulks are no longer secured to the pontoons by lashing, but in the same way as in the British service.

(2). Ribands and rack lashings are replaced by a wire rope and the strength of the whole bridge is thereby increased.

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(3). As regards trestles, the transom is now no longer suspended by chains from the top of the leg, but is secured to the leg itself.

As regards the divisional equipment:—A reduction in weight has been effected by the adoption of half pontoons, which can either be used as such or joined together in pairs to form single pontoons; this latter process is necessary when building bridges with the "normal" width of bay of 4½ metres. Thus, each pontoon wagon now carries a half pontoon and half the superstructure for one bay, is drawn by 4 horses instead of 6 as heretofore, and can carry in addition 4 pioneers.

In consequence of the lesser number of horses per wagon, the total number of horses and length of the column along the road has not been materially increased, although there are now 21 vehicles instead of 15. The advantage is moreover gained, that, should the bridging train be required anywhere in a hurry, it can proceed there at a trot carrying with it 60 pioneers to commence the construction of the bridge.

With the normal bay of 4½ metres, the bridge will carry all the vehicles which generally accompany troops. The superstructure must be strengthened however, without altering the length of bays, to take the 15-c.m. howitzer, of the 15-c.m. heavy field gun and of the lighter army mechanical transport.

For columns consisting only of infantry, cavalry and light vehicles, a length of bay of 5m. 80 can be adopted.

For infantry and cavalry in single file, a light footbridge of half pontoons can be employed, (3 baulks only are used in this case per bay).

The bridging capacity of the divisional train thus is:—

(1). Light, half pontoon footbridges, for infantry or cavalry in single file 60m.

(2). Bridge for infantry, cavalry and light vehicles (5m. 80 bays) 41 metres.

(3). "Normal" type 34½ metres.

(4). Reinforced bridge for heavier vehicles 21 metres.

In the case of the army troops train (1) is non-existent as there are no half pontoons; the length of (2) is 155m.; of (3) is 124½m., and of (4) is 75m.

With all its bridging trains, an army corps can cross 196½ metres with a normal bridge; or 235 metres with a footbridge. When they are used as boats, pontoons carry 18 men; for the transport of vehicles or mounted men, however, rafts of two pontoons must be formed with a capacity for 60 infantry; 7 horses and 7 riders; 1 machine gun, 8 men and the team; 1 field gun, 4 horses and 8 men; 1 heavy field gun and its detachment; or 6 heavy horses and 6 men.

The above figures are for the divisional bridging trains—from which 3 rafts can be formed. 12 rafts can be made from the army troops bridging train, and these together will ferry over 2 companies of infantry with their pack animals, ammunition cart and an ambulance; ½ squadron, or 1 battery with 1 ammunition wagon. The whole of the bridging *matériel* of an army corps can ferry over at the same time 3 companies infantry, ¾ squadron, or 1⅓ batteries with their ammunition wagons.

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The introduction of this new equipment ensures to the German Army a more rapid and surer way of crossing rivers than heretofore, and is a notable improvement in its efficiency.

A. H. Scott.

Rivista di Artiglieria e Genio.

October, 1910.

Ventilation and Heating of Military Hospitals.—Lieut.-Colonel Fenolio of the Engineers contributes a valuable and exhaustive article on the above important subject.

The technical commission instituted by the War Minister at Turin at the commencement of 1906, for arranging a programme for the conference of specialists on the question of the heating and ventilation of buildings, especially in the military hospital at Turin, came to the conclusion that besides the conditions relating to the temperature of the air, the position of the stoves, and the pipes for the extraction of vitiated air etc., the introduction of pure air from the outside of hospitals should not be made at a less height than 4 metres above the level of the ground. Such precautions are indispensable to ensure that the air introduced should be free from impurities and from the gases that are found in the lower strata of the atmosphere of a great city. The wards for common and infected diseases and those for surgical operations having their floors raised about 1·80 metres above the ground, it follows that in all these buildings the air should be introduced at a height not less than 2 metres above the floors.

The air introduced at a low temperature has to be heated to a temperature suited to the different localities. The verandahs and corridors should have a temperature of 15° and 18° centigrade; the wards for surgical operations of 30° centigrade.

An aperture for the introduction of the air at a height of 2 metres above the ground floor opens to a vertical pipe within the walls, which descends to the level of the ground floor and is then conducted horizontally to the centre of the hospital where the air is heated in a stove and passes into the surrounding atmosphere.

Data for the Problem.—The following data are taken from an examination of the process of heating and ventilating the military hospital at Turin:—(*a*). A vertical pipe 2 m. in length leads into a horizontal conducting pipe length 4·50 m., which opens into the centre of the hall into a stove and radiators. The total length of the conducting tube may be said to be 7 m. (*b*). The external air passes through the conducting tube to the stove where it is heated, and expands in a room 9·10 m. in length and 5·50 in height, or a section of 50 m.^{2}. (*c*). Two extracting pipes which should not be at a height above 10 m. should be sufficient to give the required ventilation. We are here speaking of wards for 12 beds, and if two ventilating stoves are supplied each will serve for 6 beds. One

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extraction pipe is supplied for each stove. (*d*). The ventilation recognized as necessary and sufficient for the salubrity of a hospital for common diseases, was established at 80 m.³ per bed and per hour. So that we have to introduce into the hospital for each stove $6 \times 80 = 480$ m.³ of air or a volume per 1″ of $V = \frac{480}{3000} = 0{\cdot}134$ m.³. (*e*). The stoves are of metal with radiators and are covered at the top with marble slabs which serve as a table. The measurements are about 1 m. in height, 1·20 m. in length and ·50 m. in width. Two openings of the same length as the stove or 1·20 m. give exit to the heated air. (*f*). The temperature of the hospital is fixed at a minimum of 15° centigrade, and a maximum of 18° centigrade when the external temperature at Turin is at its lowest, or about—10° centigrade. (*g*). The dimensions of the pipes or channels for the introduction and extraction of the air are not precisely stated. In one of the specifications presented to the Commission the section of the channel is given as 0·20 m. × 0.20 m. or a superficies of ·04 m.². Such a section would be quite insufficient. The least section of the channel for the introduction of the air should be 0·3 m. × 0·3 m. = 0·09 m.², and the same for the extracting tube.

Elaborate calculations with detailed drawings and sections are given for the calculations of the temperature; of the sections of the pipes for the introduction and extraction of the air; and for the velocity of the extracting current, but want of space would prevent these being given in detail in this Journal.

The results obtained from the calculations are important since they show that the ventilation, notwithstanding the tortuous course of the air admitted into the hospital, may function regularly, provided that the channels or pipes for the admission of the air have a section not less than S = 0·09 m.².

MISCELLANEOUS.—*France.—New Military Aeroplanes.*—We learn from the *France Militaire* of the 6th September that the French War Minister has sanctioned the acquisition of 10 Bleriot monoplanes and 20 Farman biplanes, which should be able to carry two passengers besides the pilot. France by the end of the year should have at its disposition 60 aeroplanes. It is also stated that the military aerostatic service, under General Roques has decided upon the principal characteristics of the new model of aeroplane which will be brought into service in the French Army next year. These characteristics are as follows:—the military aeroplane type 1911 should carry at least 300 k.g. and should be able to fly at least 300 k.m.; with a velocity of 60 k.m. per hour. A prize of 100,000 francs will be given for the production of an aeroplane which will satisfy the required conditions. With regard to the cost, General Roques asserts that it will be greater according to the greater velocity of the aeroplane. and considers that as one of the principal conditions of the stability and of the perfection of the apparatus.

REVIEW OF BOOKS AND PERIODICALS.—*Impressions of the Great Italian Manœuvres of* 1910.—Publications of the Military Library, Rome, 1910.—

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The author of this work, Major Enrique Patiño, Military Attaché to the Legation of Uruguay, is well known in Italy as an able writer on military subjects. The book under review, as the title indicates, gives an account of the great Italian Manœuvres of 1909, at which the author was present as a foreign military attaché, and gives a clear and vivid account of the manœuvres. The author traces rapidly and artistically a picture of the manœuvres, and the book is adorned with historical records on many points and considerations of a military nature. He traverses the classic theatre of the operations, gives lists of the generals and the troops, and explains the general nature of the operations terminating in a decisive battle.

The book has been very well received in Italy where the writer is esteemed as a man inspired with a warm and generous friendship for Italy.

EDWARD T. THACKERAY.

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CORRESPONDENCE.

RESISTANCE AND "DRIFT" OF A BULLET.

SIR,

The *R.E. Journal* of January, 1911, contains an article by Lieut.-Colonel R. de Villamil, late R.E. The subject is one of public interest and many efforts have been made to elucidate the "drift" and other phenomena of a projectile in flight.

On page 15 is an explanation of "drift," which is described by the author on page 16 as "simple and interesting and has not, that I am aware of, been previously presented."

The proof is "simple," because all effects of air friction have been ignored and the gyroscopic effects have been considered as though the projectile were travelling *in vacuo*. The proof given in the article has been well known for years; it is found in Crabtree's book on gyroscopes and spinning tops; also the Textbook of Gunnery, 1883 and 1897, contains similar proofs.

The proof given by Lieut.-Colonel de Villamil offers no explanation for projectiles which have drift to the left, such cases occur occasionally: no explanation of a satisfactory character has yet been given for such cases.

On page 15 the following paragraph occurs:—"For reasons which I cannot enter into very fully at present, the bullet is chiefly held up in the air by its rear end . . . , by the vacuum formed there acting as a kind of sucker." It is a pity that no explanation whatever is given of the theory which is put forward in this paragraph.

I am, yours truly,

C. E. PHIPPS, *Major, R.A.*

Ordnance College,
Red Barracks, Woolwich,
6th January, 1911.

The Editor, *R.E. Journal.*

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OBSERVATION LAND MINES.

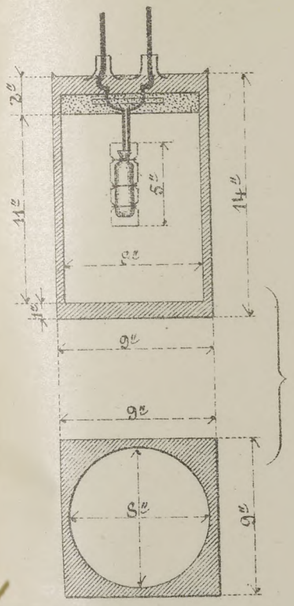

FIG. 1.

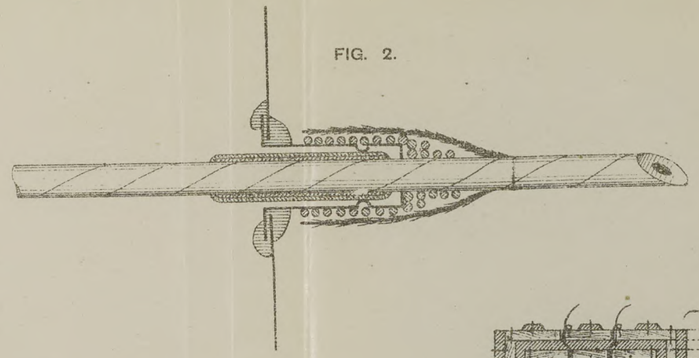

FIG. 2.

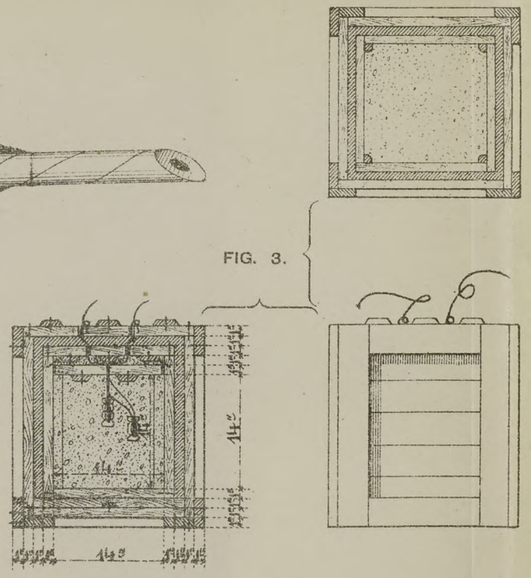

FIG. 3.

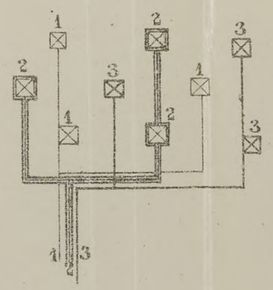

FIG. 4.

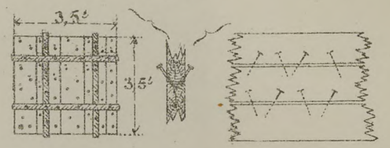

FIG. 6.
Shields.

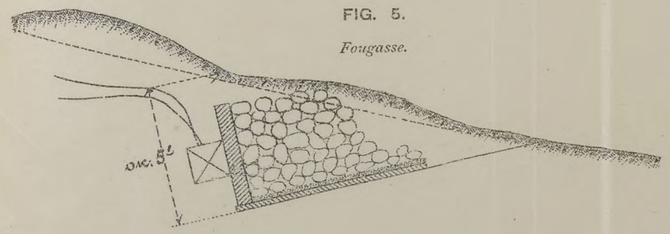

FIG. 5.
Fougasse.

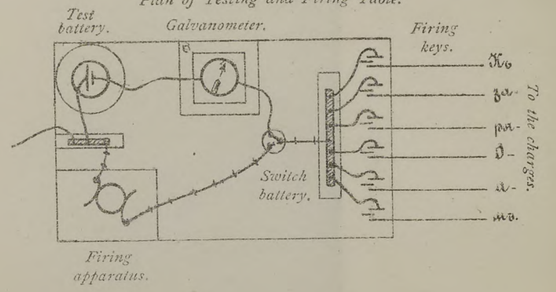

FIG. 7.
Plan of Testing and Firing Table.

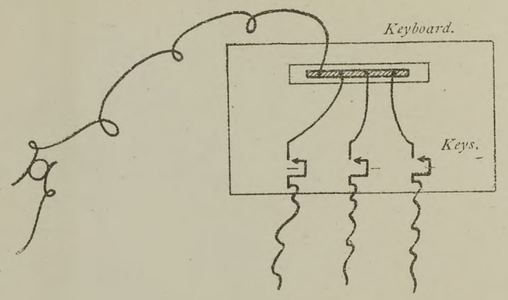

FIG. 8.
Field Keyboards.

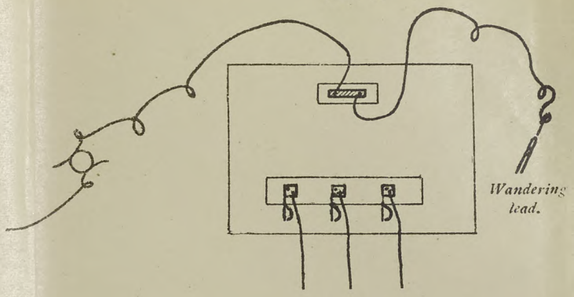

FIG. 9.

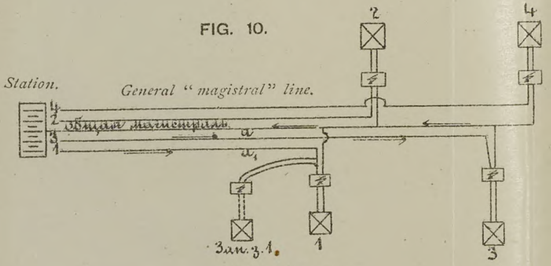

FIG. 10.

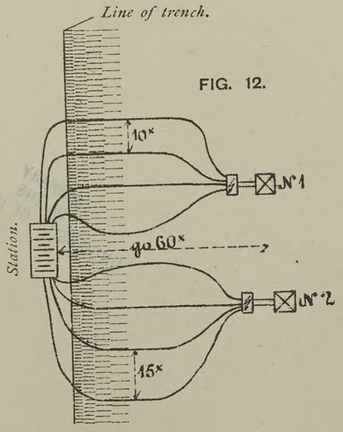

FIG. 12.

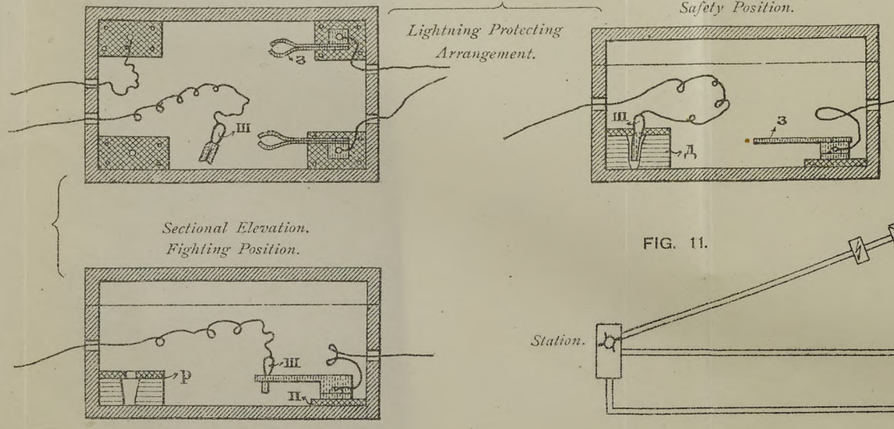

FIG. 13.

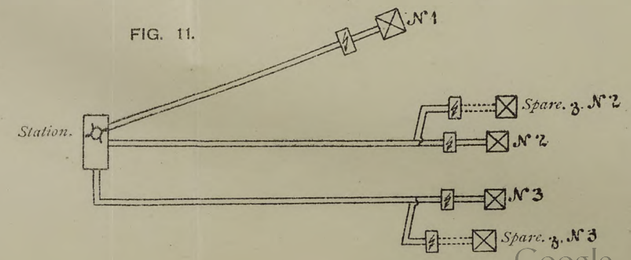

FIG. 11.

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THE PEAK CABLE TRAMWAY AT HONG KONG.

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THE PEAK CABLE TRAMWAY AT HONG KONG.

By Lieut. E. St. G. Kirke, R.E.

The Peak at Hong Kong is the highest point of a ridge, between which and the harbour, the town lies. On its slopes are several residences, an hotel, barracks for four companies of British infantry, and an Officers' Mess. To meet the considerable traffic with the town below, the Peak Tramway was built in 1888, running from St. John's Place Garden Road to Victoria Gap a pass over the ridge. From the foot to the summit the line rises 1,207′ in a total length of 4,690′. The maximum grade is 1 in 2, and the minimum 1 in 25. There are three intermediate stations, the top and bottom ones of which are so placed that when the descending car stops at one, the ascending car is opposite the other. The time taken for the trip, including stops, is nine minutes.

The alignment involved a certain amount of rock cutting and embankment. It was found impossible to avoid curves, the radius of the maximum being of 300′, and of the minimum 600′.

2. *Track.*—The track consists primarily of two 30-lb. rails of 5′ gauge held to steel sleepers, 24 lbs. per yard, by clips and $\frac{3}{4}$″ bolts. The rails can be of such light section owing to there being no power applied through them. Midway between termini is a crossing station giving 130′ in the clear, above which the track is formed of three rails. The middle rail is common to both cars and does away with the necessity for points above the crossing. Three lines, however, are unnecessary, as the ascending and descending portions of the cable can be kept from fouling by placing them to their own side of the centre of a single track. In the Stanzerhorn Metre Gauge Railway the cable runs 6·66″ off the centre. Apparently the centre of gravity of the cars is not placed 6·66″ off the centre to correspond, although such an arrangement would neutralize the additional flange friction caused by the eccentricity of the cable. The narrower the gauge the more will such flange friction be aggravated for a given cable eccentricity. In the Stanzerhorn line points are eliminated at the crossing by giving the outer wheels a double flange. The inner wheels have none, but are wider to ensure their keeping to their rail. It may be that the lesser curvature of this line has made the two-rail system possible, as in only one of its three sections is there a greater curve than of 10 chains radius, namely $7\frac{1}{2}$ chains, and on this, the first section the maximum gradient is only 1 in 3·7.

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In the Peak line the usual self-acting switch below the station has been replaced by a hand-operating one, as in rainy weather the former was found to get jammed by *débris* coming down the hill-side.

Between the running rails is a brake rail of 66 lbs., also clipped to the sleepers and standing 7″ above them. On this rail grip the differential-screw brakes, either of which is capable of stopping the car on the steepest gradient and in the wettest weather, in a few feet. Near the summit is another rail, between the running rails, of 15 lbs., to carry one pair of wheels of a light trolly which plays an important part in holding down the cables over a concave section of the line. The other pair of these wheels runs on the brake rail.

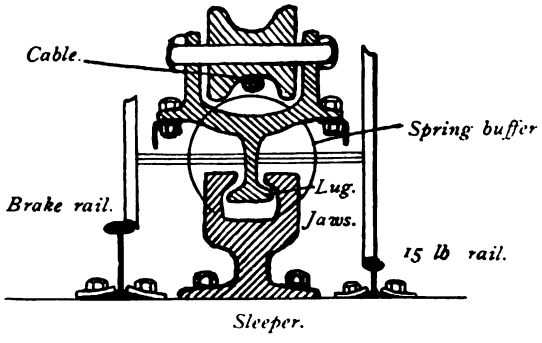

Diagram of Light Trolly.

This trolly consists of a frame carrying the holding-down pulley, attached to the axle of which is a lug to engage jaws on the track at the point where a sudden concave change in the gradient makes it necessary to keep the cable down. A spring buffer in the trolly engages with a corresponding one on the car. Normally the trolly rests in the jaws on the track. After the car ascends to this point, it pushes the trolly ahead of it to the summit, and drops it again on the return journey. The holding-down pulley must be movable or the car could never get beyond it.

3. *Power.*—The power house is at the summit, and contains two horizontal locomotive-type non-condensing compound engines of 180-B.H.P., placed on each side of the winding gear. The boilers, whose working pressure is 120 lbs., are superimposed. Either engine can be coupled to the winding gear through the flanges at F_1 and F_2. Each engine is used alternately for a month, the idle one being overhauled, and its boiler washed out. Little trouble is experienced with the latter operation as only drinking water is available for use. The high-pressure cylinder is of 13″ diameter, the low 20″, and the stroke 24″. At the end of each crank shaft, remote from the winding gear,

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is a heavy fly wheel, which takes the place of the driving wheels of a locomotive so far as balancing the engine is concerned. Power is transmitted to the four-grooved winding drum C, through the gear wheels A and B, (ratio about 1·3). D, with three grooves, is not power driven but merely follows C. The wheels B and C were originally cast together in two semi-circular halves, keyed to their shaft, and bolted to each other. The keys were, however, constantly working loose and the iron of which the drums were cast, was found to be too soft. In the present installation all the three wheels A and B and C are of cast steel. B has been cast

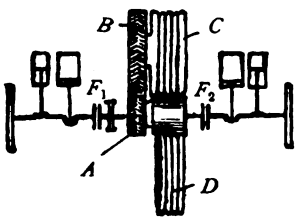

Diagram of Winding Gear.

in one and is pressed hydraulically on to the shaft. C is cast in two parts which are bolted to each other, and to B, by 2″ bolts. In addition, B and C are keyed to the shaft as an extra precaution, each by two keys. The casting upon which the toothed pinion A is carried, is prolonged to form a roller A, which runs between the drums C and D, keeping them apart and so relieving the pressure on the inside faces of their shaft bearings. This it does so effectually, that only once, since the plant was installed, have the driving drum brasses been renewed, and those of the following drum never. Cast with A also is a brake drum G, on which runs a brake band fitted with hard wood blocks. B, C and D are all three of the same diameter, 8′ 4¼″ on the pitch circle. The grooves allow the cable to lie quite freely on them. If they gripped it in any way, the outside wires would quickly become crushed and broken, rendering the cable's life a short one. The drum D is canted 2·75″ off the vertical so as to bring all the tangential portions of the cable parallel. This cant prevents the drum D being used as a guide pulley for the outgoing length of cable, and three small auxiliary pulleys are provided to keep the cable off the drum. The cable takes three complete turns round the two drums, both outgoing lengths leaving the rear or driving drum. There is no pressure-equalizing device as in the case with street cable-car installations. The load is steady and not liable to the sudden fluctuations which occur when a car grips or releases the cable at some intermediate point of the line.

4. *Cable.*—The steel haulage cable is of 3½″ circumference, and weighs approximately 2 lbs. per foot. It is formed of 6 strands

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wound round a tarred hempen core. Each of these strands is made up of 16 wires, namely 8 crown, 7 inner, and 1 central. These are given the "Lang" twist, *i.e.* they are twisted in the same direction to make the strands, as the strands themselves are, to form the cable. The surface of the cable, thus formed, in contact with the winding drums and pulleys, is greater than that given in the "Standard" twist, in which the wires are wound in the opposite direction to the strands.

The breaking strain is 45 tons, and the working stress with full load 6—7 tons. Its life varies from 3 to 10 months according to make and quality. The total length is over 5,000′ of which 400′ is round the drums. This life is much shorter than is usual with cable railways. Two years may be reasonably expected, and as much as 10 years' work has been got out of one rope. The friction round curve pulleys shortens a cable's life considerably. A broken crown wire declares itself by giving a click as it passes over the pulleys. No notice is taken of single breaks if they are more than 3′ apart, or occur in different strands. If however as many as six crown wires are broken in one strand, within a distance of 3′, this strand becomes slack, and the rope must be replaced. In England it would be possible to remove 20′—30′ of the defective strand and splice in a new piece. But this cannot be done successfully in Hong Kong. If eight crown wires are broken in different strands, within 3′, it is deemed advisable to replace the cable. Along the track, the cable is supported by cast-iron pulleys (bolted to the sleepers) which are made as soft as possible so that they shall wear sooner than the cable. The latter is lubricated during three trips every day, by dripping special oil on to it as it passes over the winding drums. This takes about one gallon of oil daily. During the first week in use a new cable stretches 10′—12′, and has to be taken up. After six months' running this has generally to be done again. The pulleys are of various shapes and sizes to suit the exigencies of the alignment. Their spindles are of specially hard steel.

5. *Rolling Stock.*—This consists of two cars one of which ascends while the other descends. Each is capable of accommodating 45 passengers on seats placed transversely. The car runs on two bogies (the wheels of which are coupled together to increase the braking power) and lies parallel to the track, *i.e.* the downhill end is not raised in any way to compensate for the gradient. At first sight this might seem a very uncomfortable arrangement, but in practice it rather serves to diminish the sense of the steepness of the hill. The frame of the car is of channel steel, stiffened by two longitudinal angle steel members. These latter were not originally provided, but were subsequently found necessary to prevent the car "hogging" under a heavy load. A transverse steel plate in the centre of the frame carries the bracket to which the cable is

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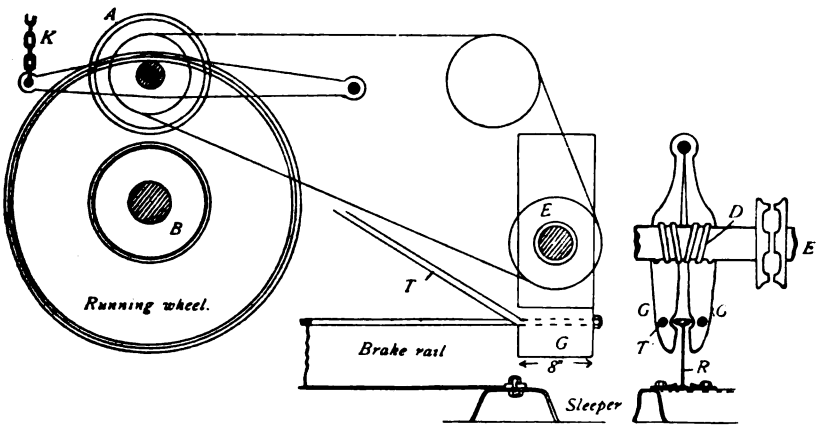
attached, the end being clamped round a thimble. Fully loaded, the car weighs 8 tons. Its superstructure is of teak.

The braking system is simple and efficient, and ensures the brake always being in operation unless *held off* by the brakesman. It consists primarily of two pairs of grippers G, one at each end of the



car, which are held just free of the brake rail R when the car is running. These grippers are actuated by a differential screw D, which is itself turned by the chain C, connected to a phosphor-bronze pinion A. A is held out of engagement with a similar pinion B, in one of the bogie axles, by the brakesman holding down a lever connected with the chain K. This one lever holds off both brakes and, directly the brakesman releases it, the pinion A drops by its own weight and engages B, when the whole weight of the car, directly it begins to descend, is utilized in closing the grippers, and the downward motion is arrested. The pinion A contains a ratchet free-wheel device which prevents its turning the chain C when the car is ascending. This obviates all possibility of the winding gear working against the brake. The grippers are stayed with the tension rods to the frame of the car.

These powerful brakes are only called into operation if the cable breaks, an eventuality which need never be feared if it is properly inspected. The passengers have the satisfaction of knowing, however, that their safety is assured whatever may happen.

6. *Running Arrangements and Miscellaneous.*—The engine driver in the power house has complete control of stopping and starting, in the ordinary course of events. He stands on an elevated platform above the winding drums and has the throttle, reversing, and brake levers under his hand. In addition he has a chart whose moving pointers, gear driven from the engine shaft, show him the exact position of each car on the track. The stations are marked on the chart so that he knows when to stop, should he be required to do so

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by either brakesman, who signifies his desire by ringing a bell in the engine room. This bell circuit is completed by pushing out from the side of the car a light frame carrying a vertical copper rod, which makes contact with two bare copper wires, carried parallel to the track on standards spaced 100' apart. The terminal stations are connected by telephone. At intermediate stations either brakesman keeps his bell ringing as long as he wants to stop. His ceasing to ring is the signal to the engine driver that he is ready to start. If he notices anything wrong between stations he rings to stop, and releases his brake lever. If, owing to the cable slipping round the drums, or for any other reason, the pointers on the chart come out of adjustment, they can always be made to indicate correctly by a simple compensating device.

The governor originally fitted to the engine has been dispensed with, and the engine driver judges by ear how fast the drums are turning. A speed indicator would possibly be found useful when training new men. The running speed is from 6 to 9 miles an hour, and a reserve of power is always available by simpling the engine.

The cars run every quarter of an hour from 7 a.m. until 11.15 p.m., with breaks when there is no traffic. As many as 75 double trips have been made in one day. Except in the early morning, the line is used exclusively for passenger traffic, and it frequently happens at busy times of the day that some would-be travellers have to wait for the next train, unless they care to take a special between the regular timings. When nearing the summit the ascending car releases a trigger on the track, which rings a bell in the engine room. This is useful to warn the driver on a dark night or in foggy weather; ordinarily he can see a good distance down the track.

The staff required to work this system is very small. In addition to the Superintendent, there are two engine drivers who receive 150 Mexican dollars per month, with, say, 20 dollars extra for overtime; four brakesmen, whose average wage is 130 dollars (these six must be European by Government order); four stokers, and a few coolies. The daily expenditure including depreciation is $120. Coal consumption varies very much with the kind used, from 1 ton daily of the best Tonkin coal, to 2½ tons of Japanese.

So successful has this tramway been in operation, that the Directors are contemplating another larger one to take up 60 passengers and to enable the present one to be used for goods.

The cost of the present installation was about £20,000 and it is interesting to note that the shares were 3½ times their original value within one month of the opening of the line, and have not since depreciated.

A few improvements are embodied in the designs for the proposed new plans, and among them is the use of grooved slip rings on the drums. These ensure that any wear due to slip will take place

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between the rings and the drum, instead of between the cable and the drum. Grease is forced in between these rings and the drum by screw lubricators.

Many of these cable railways exist in different parts of the world, notably in Switzerland, where the Stanzerhorn Railway rises 4,594′ in about $2\frac{3}{5}$ miles. In South Tyrol the Mendel Railway rises 2,700′ in 2,600 yards.

The special function of cable railways is to surmount big elevations in much less time than can be done by any other known method. This they do by virtue of the steepness of the incline at which they can be laid, and the directness of their alignment. 1 in 8 is the economic maximum at which rack railways can be laid, and about 1 in 40 for adhesion lines. The Marseilles Cliff Railway, worked by water counterpoise, rises at a slope of 1 in 0·58, or nearly 60°, and 1 in 1·6 is the maximum grade on both the Stanzerhorn and Mount Vesuvius Railways. (The central racks in the Marseilles Railway are for controlling the cars; no power is applied through them).

It would seem that the problem of transport to Indian hill stations could be largely solved by the aid of cable railways. One hundred feet a minute may be taken as fair average lift for cable railways, including changes at the junction of sections.

In siting railways of this kind, the alignments should be as straight as possible to avoid pulley friction, and the gradient should become steeper as it ascends, to form a parabolic curve, so that the extra length of cable of the descending car may by its weight assist the ascending one up a correspondingly increasing gradient. This arrangement means an uniform speed with an uniform and minimum expenditure of power. In the Hong Kong line the maximum extra weight of cable is nearly 4 tons. The three sections of the Stanzerhorn Railway all approximately follow a parabolic curve. Its gradients are :—first section, (866′ rise), 1 in $12\frac{1}{2}$ to 1 in 3·7; second, (1,664′), and third, (2,064′), both 1 in $2\frac{1}{2}$ to 1 in 1·6. It must be a matter of considerable experience to determine how great a departure from the theoretically perfect gradient can be made to avoid heavy cutting or embankment, which would make a great difference in the first cost, but in no place should a concave change of gradient be made which greatly exceeds the catenary of the cable, or recourse must be had to holding-down trollies—as at Hong Kong—which are an undesirable complication. By placing the winding gear in the middle of two sections, only one car need be used on each and the cable can be central, but the traffic capacity is reduced by half. Another advantage is that coal, etc., has only to be lifted half the distance. With a single section the power house can be placed at the bottom, but double the length of cable is necessary. The nearer the gradient approaches the theoretically perfect, the less are the wear and tear of plant, and maintenance charges.

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Aligning the track down or near a spur will largely eliminate the possibility of damage by the heavy rainfall which occurs in tropical mountainous countries. About £25,000 per mile may be taken as the cost of constructing a cable railway, and since this does not vary proportionately with the steepness of ascent, the steeper the gradient the more economically will any given difference of level be surmounted. Within limits, multiplication of sections makes for increased traffic capacity, in the same way that the number of crossing stations does that of a single railway line.

In conclusion my warm thanks are due to Mr. Buyers, the Superintendent of the Peak Tramway, for placing his great knowledge and experience so unreservedly at my disposal during a recent brief visit to Hong Kong.

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THE WORK OF THE R.E. IN THE CHINA OR "BOXER" WAR OF 1900—1901.

A Lecture delivered by COL. F. T. N. SPRATT BOWRING, C.B., LATE R.E., *at the S.M.E.*

MUCH has been written in explanation of the origin and rapid development of the Boxer Movement in 1899 and the early part of 1900, which brought about the China War, in which six European Powers, together with America and Japan, were involved. There is, however, but little doubt that the phenomenal growth and acquisition of strength by this Militant Association was due, in the first place, to the Chinaman's traditional hatred of the "Foreign Devils" who, by active hostility and diplomatic methods of "pacific penetration," were gradually acquiring territory, concessions and rights, which the Chinese believed threatened the very existence of their Empire. The pride of race, the exclusiveness, the self-contained habits of trade, business and commerce, and the antiquity of their forms of administration, laws and methods of thought, can only be understood and appreciated by those who have visited the country and given time to the study of these national characteristics.

The soil was ready to receive the seeds of foreign hate and mistrust which were scattered broadcast by the Boxers, and which took root and shot up as rapidly as that common native millet, known as "Kaoliang," in the springtime.

The first indications of the coming events showed towards the end of 1899, when Mr. Brooks, a missionary, was murdered. During the early part of the following year, further outrages were perpetrated upon the foreigners, but not until the summer did matters become really serious, when anti-foreign disturbances manifested themselves prominently in the provinces of Shan-tung and Pei-chi-Li. Wei-hai-wei, in the former province, was in occupation by the British, having lately been handed over to them by the Japanese. Brigadier-General A. R. F. Dorward, R.E., was in command of the station, and it is here that the Corps of Royal Engineers first comes in contact with the Boxer rising. Major C. Penrose, R.E., was engaged upon the survey of the concession on the mainland, and while thus occupied on the 5th May, 1900, his survey party was unexpectedly attacked by a mob

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of Chinamen, and he was severely wounded, together with four of his men. At about the same time the Boxers began to show such decided hostility in and about Pekin, that it was considered advisable to increase the strength of the Foreign Legation Guards by reinforcements from the fleets, and these reached Pekin on the last day of May.

The situation grew rapidly worse, and early in June Admiral Seymour with a small force made an attempt to reach Pekin by the railway, but meeting with determined hostility was checked when about 30 miles from Pekin, and had to fight his way back to Tientsin. Between the 16th and 18th June news reached Wei-hai-wei of the critical position in which Admiral Seymour's force was placed, and General Dorward was ordered to despatch 200 men of the Wei-hai-wei Chinese Regiment, and a detachment of R.E. of the 25th Company to Tientsin. A few days later he was directed to proceed there himself and take command of the British troops.

Hong Kong was preparing to despatch more troops, among them a section of R.E., while India, in hot haste—and in the hottest weather—was getting together the British Expeditionary Force. The Wei-hai-wei and Hong Kong Sapper sections were under the commands of Capt. R. P. Lee and Lieut. F. M. Browne respectively, and arrived on the 21st of June at Tang-ku, the port or landing place for Tientsin on the river Pei-ho and about 30 miles lower down the river by rail. Reinforcements from Japan under General Fukushima and Russian troops under General Vogak reached Tientsin about the 20th June.

The outlook at this critical period was indeed gloomy enough to make the stoutest hearts doubtful of the future. Tientsin City, some 3 miles higher up the Pei-ho than the settlement, was given over to the Boxers, and large bodies of Chinese troops were known to have either entered it, or to be on the outskirts, evidence that the Celestial Court had also joined the rising against the foreigners. The concession itself was being threatened on all sides, and Admiral Seymour's column, which was fighting its way back to Tientsin, was sorely in need of help. Railway communication with Tang-ku had been cut, and the Pekin Legations were besieged by thousands of Chinese thirsting for their blood.

The extreme gravity of the situation drew the foreign elements together in strenuous efforts to save the situation and their own lives. Tang-ku set to work to open communication with Tientsin ; Tientsin sent out relief to Admiral Seymour's column—which returned on the 26th—and made every effort to put the concession in a state of defence, hoping to be able to hold out till reinforcements arrived.

Dorward and his two Engineers, Lee and Browne, with their Sapper sections, were untiring in their efforts to make the place as strong as circumstances, materials, men and time would permit. The foreign

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area lay along the river on the right bank, and was enclosed to the west by an embankment raised against floods. These were the two main features taken advantage of in the defence, with the railway station, which was unfortunately on the other bank about a mile distant, but could not be omitted from the already unduly extended area to be defended by so small a garrison.

Between the date of their arrival at Tang-ku and the 14th of July, when the Tientsin City was taken after two days' hard fighting, the handful of Sappers, assisted by such local labour as they could procure, were engaged on the defences, the railway, the battery positions, the naval gun mountings, water supply, telegraph and telephone communications, and a variety of other useful work. On the 6th Lieut. Browne was wounded.

During the bombardment of the Foreign Concessions in Tientsin, which lasted upwards of 10 days, the destruction was enormous, many of the large mercantile stores being set on fire and others wholly wrecked. The Chinese artillery was admirably served and their information about the movements of the foreigners was evidently most correct.

During the attack on the city on the 13th and 14th, General Dorward was in command of the British and American troops together with a few Austrian Marines, numbering in all about 1,700 men.

The capture of Tientsin City and the arrival of further reinforcements had an immediate effect upon the situation; it relieved the local strain and extended even to Pekin, where active hostilities against the Legations ceased for a time. Better counsels, known to have been at work, were evidently influencing the Court circle, and belief in the irresistible Boxers was diminishing.

As soon as order was established in and about Tientsin, the thoughts of all turned to considerations for the relief of the Legations, but there were great divergences of opinion as to the strength of the forces needed to accomplish it. The R.E. were mainly occupied in preparing Chinese junks for the transport of stores up the Pei-ho, as the troops simultaneously advanced by the river route to Pekin, and in repairing and assisting to work the railway to Tang-ku.

The contingent from India began to arrive on the 18th July, and Major (local Lieut.-Colonel) G. K. Scott-Moncrieff, the C.R.E., arrived with the Headquarter Staff on the 27th of July.

Due to various causes, the three Sapper companies first told off to the expedition were late in their embarkation from Calcutta, and did not reach China in time to take part in the advance to the relief of the Legations, when their services would have been of great value.

The R.E. on the spot set to work to improvise, mainly from local resources, the engineering requisites for the advance to Pekin *viâ* the river; the railway, rolling stock, and several bridges on the line to

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Pekin having been hopelessly destroyed and made unrepairable within any reasonable time.

By the 4th August the preparations of three of the Allies at least, viz., British, American and Japanese, were complete, and the advance commenced on that day. The Russians and French at first declined to co-operate, but when they found that the others were proceeding without them, they joined forces, and advanced by the left bank, the other three keeping to the right.

On the 5th August the Chinese defended the entrenched position between the Pei-ho and Wun-ho Rivers with considerable tenacity, the brunt of the attack being borne by the Japanese with the British in support. These allied troops lost some 325 killed and wounded in the assault. Pursuit was rendered difficult by inundations, in the crossing of which the want of Sappers was severely felt. On account of this obstruction the whole allied force was obliged to retire for some distance and to cross (by means of a bridge of native junks hastily put together by the R.E.) to the right bank, resuming their march next day on that bank. Further Chinese resistance was made at the village of Yangtsun (at which place the railway crosses the Pei-ho) where the embankment approaching the bridge was held by the main Chinese army, who had also constructed gun pits and other earthworks to supplement the railway embankment. The attack on these was carried out successfully mainly by the British, supported by Americans and a few Russians, with a loss of about 130 killed and wounded.

The Allies then recrossed the river to the right bank, along which the rest of their march to Pekin continued. At Ho-shi-wu on the 8th the enemy were preparing a further entrenched position but were surprised by British cavalry, who made a successful charge on their flank. The position was hastily evacuated, the enemy leaving their tools, and a large powder magazine containing from 80 to 100 tons of powder, was captured and destroyed by the R.E. Three (subsequently increased to five) defensible posts were established by the British force on the line of communication between Tientsin and Pekin, the work being done as far as possible by the R.E. as they advanced, and afterwards strengthened by the Madras and other Sapper companies as they followed on. The march lasted 10 days, and the relief of the Legations took place on the 14th of August, the British troops being the first to enter the area defended by the Legations.

The following R.E. officers took part in the march to Pekin:—Lieut.-Colonel G. K. Scott-Moncrieff (C.R.E.), Capt. R. E. Picton (Adjutant), Capts. G. H. Griffith, R. P. Lee, C. H. D. Ryder, and Lieut. S. G. Loch. Lieut. H. Cowie remained at Tientsin with his railway section to assist in repairing the line to Tang-ku.

At Tong-chu, 16 miles from Pekin, the road leaves the river

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route, turning west. Along this the Allies advanced to the attack of Pekin, their objective being the city gates on the east and north in the following order. The Russians made for the north gates, the Japanese the east gate of the Tartar City, the Americans the corner where the Chinese City wall joins that of the Tartar City, and the British the east gate of the Chinese City. The French were in reserve.

A small party of Engineers with their tools and explosives were with the British advanced party to blow in the gate if necessary, but as it was found to be unguarded, an entrance was easily obtained by scaling the walls. The British force then pushed on through the streets of the Chinese City, with little opposition, to the main drainage exit of the Tartar City through which they entered. This portion of the city wall was fortunately still held by the troops of the besieged Legations.

During the advance from Tientsin there was neither time nor means for carrying out engineering works of importance, but such as could be done was effectually put through; the presence of a strong company, however, well to the fore, would on several occasions have been of very great assistance to the troops. The Telegraph Section, under Lieut. Loch, R.E., in conjunction with the American section, under Lieut. Stamford, kept the head of the column in touch with the base, to within 30 miles of Pekin, and had the C.R.E. been allowed to take the second junk load of stores, as he earnestly requested leave to do, the same evening as the relief took place, through communication with Europe would have been established.

A useful form of field observatory was devised by means of two bamboo ladders tied at the head, which could be raised to a height of 30′ to enable an observer to overlook the flat country which at that time of year was mostly covered with millet 10′ high, blocking out all near view. Four of these were carried by the Sappers in the advance, and were of great assistance in locating the enemy and in directing the fire of the artillery. A captive balloon attached to the advancing junks would have been invaluable, but the Balloon Section did not arrive in time to be of any practical use throughout the operations.

During this period, in addition to the R.E. already named, the following Sappers rendered excellent service :—Sergt. R. Bowery, Corpls. G. Watkins and R. Wareham, and Sappers J. Tranter and A. Elliott.

When Pekin and the neighbourhood had been cleared of Boxers, the apportioning of the spheres of responsibility between the Powers settled, and a decision arrived at that the whole force should winter in China, then the definite and most arduous work of the Engineer officers began.

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The transition from autumn to winter in this northern Chinese province is very sudden. Towards the middle or end of November the Pei-ho becomes frozen over, and the whole coast line of Pei-chi-li Bay becomes icebound for some miles to seaward. Various rumours were afloat as to the severity of the cold and the hardships to be faced. The provision made by the Chinese themselves for keeping their houses warm, with double doors and windows, and their arrangements for heating their sleeping platforms, clearly indicated that special precautions were necessary. The British Indian troops being drawn from all parts of India, it was a matter of considerable anxiety and uncertainty how they would stand the severity of a North China winter.

More troops were on their way from India, increasing the British contingent by one brigade, to make up for the troops unexpectedly diverted at Shanghai, as well as to bring them up to a more proper level with British interests in the East. Colonel W. T. Shone, R.E., was ordered out as Colonel-on-the-Staff, R.E., to be replaced soon after by Colonel F. Spratt Bowring, R.E., on the former being appointed Inspector-General Military Works in India.

The chief centres of winter housing operations taken in hand at once were Pekin, Shang-hai-kuan, Tientsin, Shanghai, and Wei-hai-wei. Before detailing, however briefly, the work that now fell to the Royal Engineers, we must note the order of arrival of the belated companies.

The first to reach the field of operations was the 4th Company of Bengal Sappers, commanded by Capt. H. R. Stockley with Lieuts. C. M. Carpenter, H. D. Pearson and M. R. Elles as company officers. They reached Sinho on the 5th August, after a delay of three days at Wei-hai-wei to land the Native General Field Hospital. This company was embarked at Calcutta without its own transport, and although promised it on arrival in China, it was not then forthcoming. The minimum of transport should invariably be sent with each company to avoid such mishaps.

The next was the 3rd Madras Company, which arrived on the 8th, together with the Printing and Photographic Sections. The company was commanded by Capt. J. A. S. Tulloch with Lieuts. E. G. Henderson, R. E. Goldingham and T. A. Garstin, the company officers.

Three days later No. 2 Bombay Company arrived at Tientsin with the following officers:—Capt. G. H. Boileau commanding, and Lieuts. G. R. Pridham, J. E. Craster and W. B. Chaldecott, company officers. This company experienced very rough weather on the way out and their transport animals suffered somewhat in consequence.

Kotla Sappers arrived last.

The 4th Bengal Company was first employed on the Tientsin defences, but on the 8th was ordered to escort a convoy of junks

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loaded with stores, by the river route, to Pekin, where they arrived on the 19th August, five days after the relief. Between that and the 6th of September they were employed in improving the communications in and about Pekin, after which they left Pekin and established themselves at Feng-tai, the junction of the branch railway to Pao-ting-foo, settling down to the work of reconstructing that part of the demolished railway line to the south in the direction of Tientsin. We must leave them there for the present, returning to the work of railway reconstruction and management later.

No. 3 Madras replaced the Bengal Company at Tientsin and dividing, one half-company was sent to the Junk Yard to continue the work of fitting these out, the other half being set to improve and extend the defences until such time as a second convoy of junks was ready for despatch to Pekin when they were sent north in charge, reaching Tung-chou on the 26th. On the way up they improved and added to the defences of the several military posts. From that date to the 11th September the company was employed in repairing the 16 miles of road between Tung-chou and Pekin, after which Headquarters were transferred to Pekin when the company and its officers, in detached charges, were engaged in the work of housing the troops. Half the company, under Capt. Tulloch, was detached for a time to take part in the Pao-ting-foo operations against the Boxers, during which they carried out a great deal of useful engineering work.

On the return of the column to Pekin early in November, the whole company was ordered to Shanghai to help with the winter housing operations at that station, and arrived there on the 26th November.

No. 2 Bombay Company took up and continued the defence work in and about Tientsin, and on the 19th August went into action with the other troops against a large gathering of Boxers who were threatening the communications to the south, and coming to close quarters with them on one flank, took three standards and a quantity of arms. When not engaged in the various punitive expeditions, such as that to Pao-ting-foo, where half the company was sent under Lieut. Pridham, the officers and men were occupied in preparing the winter arrangements for the troops at Tientsin, and adapting two large warehouses for their own use and accommodation.

In March, 1901, the right half-company was ordered to Ma-chia-poo—the Pekin end of the line—to work on the railway, at which they continued for three months, when they exchanged places with the left half at Tientsin, the latter proceeding to Pekin to work on the Legation defences. Two Engineer Field Parks had been mobilized in India, one at Roorkee and the other at Calcutta, and in due course they arrived at their destination, one being stationed at Tientsin and the other at Shan-hai-kwan, where Lieut. Watt, R.E.,

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was in charge under the orders of Major R. D. Petrie, R.E. Between the end of September and the middle of October the further reinforcements for the British contingent in India began to arrive, and with them Colonel W. T. Shone, C.B., D.S.O., his Brigade Major, Major J. G. Day who was, however, invalided shortly afterwards and succeeded by Major A. R. Reynolds, Lieut.-Colonel J. R. L. Macdonald, with the Balloon Section, Majors J. E. Dickie, C. A. R. Browne, Capts. A. H. B. Hume, A. F. Cumberlege, H. J. M. Marshall, P. G. Twining, W. A. Harrison, A. Rolland, Lieuts. H. F. E. Freeland, C. G. W. Hunter, E. C. Tylden-Pattenson, with the Mounted Sappers' Section, E. W. S. Mahon, F. G. Turner, W. A. Stokes with Kotla Sappers, T. G. Martin-Leake, E. D. Carr-Harris, and F. W. Brunner.

In addition to the above were Lieut.-Colonel Asuf Ali, in command of the Maler Kotla Sappers of the Imperial Service troops, Lieut.-Colonel G. W. H. W. O'Sullivan, R.E., on the Headquarters Staff, and Major T. F. B. Renny-Tailyour and Capt. C. H. D. Ryder, survey officers; in all 46 R.E. officers were at that time in North China.

The work of these various officers ranged over a wide area and was very diverse in character. The bulk were at first employed upon the winter housing arrangements, which had to be carried out against time, while others were engaged upon railway reconstruction and management, improving the landing facilities and the storage accommodation at Sin-ho, a pier at Shan-hai-kwan, telegraph and telephone communications, survey, staff and intelligence work and a variety of other branches of engineering, nothing coming amiss to the ubiquitous Sapper. The extent of one section alone of their work will be realized when it is stated that 18,000 troops, 14,000 followers, and 10,000 animals were provided with warm and comfortable shelter before the severe winter weather set in.

The main centres of these activities were Pekin, Tientsin, Shan-hai-kwan, Wei-hai-wei and Shanghai, and the following was the usual procedure in providing accommodation. Where possible, existing storehouses, Chinese houses or forts were made available for the troops, but in most cases the native followers were accommodated in new huts or ruined houses which were repaired, and the animals quartered in sheds erected for the purpose. Contract or direct native labour was as far as possible employed. The British officers in command of the native troops, being accustomed to provide their own regimental quarters in India, were advanced funds to engage local labour and purchase material, the R.E. lending such aid and giving as much supervision as they were able, to the work. One feature of this winter housing was the necessary provision of heating arrangements, and orders for stoves of all sorts and sizes were sent far and wide, and the Chinese method of heating by under-floor flues was also largely resorted to. No less than 2,000 stoves were in use and

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7½ miles of flue piping erected, and so severe was the cold that the drinking troughs and sentry boxes had also to be heated to keep the water in one case and the sentry in the other, from being frozen. In addition, the Commissariat was sheltered, and every staff and regimental officer provided with suitable and comfortable winter accommodation.

Accommodation was provided as follows:—

PEKING AND OUTPOSTS.

In New Buildings.

16th Bengal Lancers—Headquarters and 2 Squadrons.
Mounted Detachment, Bengal Sappers and Miners.
Commissariat Bakery and Flour Mill.

In Adapted Buildings.

Headquarters Staff, Intelligence and Survey.
G.O.C. Cavalry Brigade and Staff.
G.O.C. 1st Infantry Brigade and Staff.
New South Wales Naval Contingent.
12th Battery, R.F.A.
R 7 Ammunition Column.
4th Balloon Section, R.E.
Engineer Field Park.
Telegraph Section, "Q.O." Madras Sappers and Miners.
Railway Section.
2 Photographic Sections.
1 Lithographic Section.
1 Printing Section.
16th Bengal Lancers—2 Squadrons (1 in Outposts).
1 Company of Sappers and Miners.
7th Rajputs.
24th Punjab Infantry.
1st Sikh Infantry, P.F.F.
26th Baluchistan Regiment.
} Mules in new stables.
Hospitals—
3 Sections British Field.
1¾ Native Field.
2 Sections Native, General.
} In buildings which required extensive alterations.
Ordnance Depôt.
Commissariat Depôt and cattle.
Transport, 1,200 mules, of which 620 with followers were in new buildings.

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TIENTSIN AND OUTPOSTS.

In Hired Buildings.

G.O.C., Line of Communications and Staff.
G.O.C., 4th Infantry Brigade and Staff.
"B" Battery, R.H.A.
1-Pr. Maxim Section.
R/2 Ammunition Column } With new buildings for 400 horses and followers.
Victorian Naval Contingent.
1 Company Bombay Sappers and Miners.
Telegraph Section, Bengal Sappers and Miners.
Lithographic Section, Bombay Sappers and Miners.
20th Punjab Infantry.
31st Madras Infantry.
Hospitals —
3 Sections Native, General.
1 Section British Field.
4¼ Native Field.
Field Medical Store Depôt.
Native Base Military Depôt.
No. 5 Veterinary Field Hospital.
Commissariat Stores and Bakery.
1st Madras Pioneers.
Hong Kong Regiment. } Headquarters and portions of regiments in hired buildings, remainder in posts on Line of Communications.

In Villages Adapted for the Purpose.

3rd Bombay Cavalry.
Alwar Imperial Service Infantry.
Bikanir Imperial Service Infantry.

Partly in Hired and Partly in New Buildings.

Ordnance Field Park.
Ordnance Depôt.

Partly in Adapted and Partly in New Buildings.

Transport and Commissariat cattle.
3,400 horses and mules, and 7,000 cattle and sheep.

In New Buildings.

Provost Prison.

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SHAN-HAI-KWAN AND CHING-WANG-TAO.

G.O.C. and Staff, 3rd Infantry Brigade.
Detachment, R.G.A.
Jodhpore Lancers.
Engineer Field Park.
Maler Kotla Sappers.
6th Jats.
4th Punjab Infantry.
34th Pioneers.
Ordnance Depôt.
Hospitals—
1 Section British Field.
2½ Native Field.

Accommodated as far as possible in existing buildings which required extensive repairs and alterations. All stables for cavalry and regimental transport had to be newly built, also quarters for most of the cavalry and some of the sappers and infantry, with the majority of the subsidiary buildings for all arms. Several wells were sunk.

WEI-HAI-WEI.

(*a*). *Island.*

In Converted Existing Buildings.

1 Company R.G.A.
Printing Section, Bombay Sappers and Miners.
Balloon Gas Factory.
British General Hospital, 2 Sections.
Officers' Hospital.
Native Field Hospital, 1 Section.
Nurses' Quarters.
Officers' Quarters.
Ordnance Depôt.
Commissariat Stores.
Native Base Depôt.
Stables.

In New Buildings.

3 Companies 28th Madras Infantry.
Followers.

(*b*). *Mainland.*

5 Companies 28th Madras Infantry in Chinese Regiment Barracks.
1st Chinese Regiment in old Barracks.
1 Native General Hospital.
Medical Officers. } In hired buildings.
Transport.
500 followers—in new huts.
Infantry mules and Detention Ward—in Flagstaff Camp, converted.

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(c). Sun Island.

Quarantine station for mules.

SHANGHAI.

G.O.C. and Staff, 2nd Infantry Brigade.
1-Pr. Maxim Section.
1 Company "Q.O." Madras Sappers and Miners.
2nd Bengal Infantry.
14th Sikhs.
1st Battalion 4th Gurkhas.
30th Bombay Infantry.
Ordnance Depôt.
Hospitals—
1 Section British Field.
2½ Sections Native Field.
Field Medical Store Depôt.
Commissariat Transport and Stores.
Hospitals and two battalions in hired buildings, remainder in tents with substantial mat shelters.

No better testimony to the thorough manner in which this work was carried out could be found than in the fact that the troops, followers, and animals emerged from their winter quarters at the end of February, or beginning of March, showing a bill of health as good as, if not better than, they would have had had they remained in their own cantonments in India. This reflects the greatest credit on all concerned.

Turning next to the railway operations. The greatest possible havoc had been wrought upon the line from Pekin to Tientsin by the Boxers. Bridges had been destroyed, engines overturned and fired into, the rolling stock burnt, rails uprooted, sleepers either burnt or stolen, and everything small or great that could be lifted, carried off, or hidden away by the Chinese. At Feng-tai the railway stock and sheds were mere charred remains of their former selves, and it seemed all but hopeless to attempt the work of reconstruction.

The railway from Tang-ku to Tientsin passed through many hands and vicissitudes at the start. It was first repaired and controlled by the combined efforts of the British Navy and the R.E., but due to the weak railway section sent from India, the Russian Railway Battalion claimed and obtained control of this section.

After the relief of the Legations the Russians occupied Machiafu, the then Pekin terminus, intending to take into their hands the whole reconstruction. This view of the case did not commend itself to the other allies, and on the 30th August a small force of all arms, under command of Lieut.-Colonel Scott-Moncrieff, R.E., was ordered to Feng-tai, an important junction 5 miles beyond Machiafu, with

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orders to clear the country of Boxers, establish a defensive position and commence restoration of the line. In October, the German troops began to arrive from Europe, and with them a railway battalion, when the Field Marshal Commanding, Count von Waldersee, requested the C.R.E. of the British force to meet and confer with the German authorities as to the apportionment of work for the restoration of the railway lines. The arrangement was as follows :—To the British the Pekin end was allotted, working north and south from Feng-tai. The Japanese and Germans shared the interval to Tientsin. The Russians worked from Tang-ku towards Shan-hai-kwan, which had not been badly damaged, later handing it over to the Germans, taking for themselves that part of the railway extending beyond the Great Wall at Shan-hai-kwan, to Niuchwang. At the same time it was decided that the Pekin terminus should no longer be at Machiafu, 2 miles outside the city, but should be brought within the walls to a central station near the Temple of Heaven. Here sidings were made for the several Powers, and a careful system of traffic working inaugurated.

Lieut.-Colonel Macdonald was placed in charge of the British railway operations in October, and by dint of hard work and by making use of every scrap of material that could be procured the first train into Pekin was able to pass over the British section on the 9th December. This was but a beginning and much still remained to be done to put the line in anything like running order.

The Engineer officers at Feng-tai were greatly assisted in their work by Mr. Allardyce, the Chinese interpreter attached to them, whose knowledge of the Chinese and influence with them facilitated the recovery of much of the stolen property and the supply of new material. Capt. Twining on the Tientsin and Tang-ku section, had by great personal exertions brought that portion rapidly into fair working order. The divided system of control had not worked satisfactorily, and it was necessary to reconsider and determine upon some better method of general management of the line throughout from Pekin to Shan-hai-kwan. As this railway had been constructed with British capital and several Britishers were still on its staff, chief among them being Mr. Kinder a civil engineer of local experience, it was finally settled, after protest from certain Powers, to hand over the whole to British control alone, leaving to the Russians that portion beyond the Great Wall.

Lieut.-Colonel Macdonald was called upon to organize the staff from a combination of R.E., British civilians and Chinese.

The history of this work would take a volume to itself to properly describe ; only a man of Macdonald's go and energy could have organized in so short a time a system of railway management with such excellent results. He was appointed Director of Railways with Browne as Deputy Director, Twining as Locomotive Superintendent,

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Pekin section, Freeland Traffic Superintendent, Cowie Personal Assistant, Griffith, Rolland, and Pearson on Railway Maintenance, Hunter Wharf Master at Tang-ku, Mahon and Turner on Railway Survey, with the two half-companies of the Sappers on construction. Guards of British troops were established at all the stations and at all the bridges in defensible posts, to prevent any attempts being made to destroy the line or block the traffic. The whole length of line was also patrolled night and day.

A short extract from a report by Colonel Macdonald will give some idea of the work that was accomplished :—

"The railway from Shan-hai-kwan to Pekin is 256 miles long, and of this 120 miles of line and 11,000′ of bridging had been totally destroyed, nothing being left except the earthworks and the masonry or concrete abutments and piers of some of the bridges. Ten stations, including one changing and one terminal station, had been ruined and in the majority of instances razed to the ground, even platform walls being pulled down; rails and sleepers had been taken away, in many cases to considerable distances; the girders of every iron bridge on this length of 120 miles had been thrown down or damaged, and some 14 engines and 500 cars had been broken up or burnt, while several hundred more had been rendered unfit for use. The workshops at Feng-tai had been gutted and demolished. Almost the whole damage had been done at the Pekin end of the line, and the total destruction of the Han-kow and Mingchikee Bridges rendered it impossible to draw power or vehicles from the Shan-hai-kwan end. The additional R.E. officers who had been ordered from India, arrived opportunely, the former civil staff loyally supported and co-operated with the British Military Engineers, the Chinese employés, who had hitherto stood aloof, flocked to resume work, and by the end of March the train service had shown a marked improvement and the railway earnings more than covered the working expenses. The earnings in May reached a higher figure than that of the best month in peace before the outbreak.

"By the end of June, the British Engineers had reconstructed 14 miles of the old line, with 1,500′ of bridging, had nearly completed 29 miles of absolutely new construction, with 1,000′ of bridging, and had strengthened and improved over 100 miles of damaged line and some 9,000′ of bridging, while running sheds, shops, watering and station arrangements, staff quarters, etc., had been brought into efficient condition. Eleven new engines had been erected (9 being at work within 30 days of landing), 6 new tenders had been built, 22 engines received major and 24 minor repairs, 80 new carriages and cars had been built and 940 cars repaired. From March to June over 88,000 troops, 177,000 tons of military stores, 250,000 civil passengers and 880,000 tons of civil goods had been carried, the monthly earnings rising from 160,000 dollars in March to 270,000 in May.

"The *personnel* during this period averaged 28 military officers, 14 civil officers, 95 British N.C.O.'s and men, 17 civil subordinates, 600 Chinese staff, besides some 3,000 coolies."

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The task of the British Railway Staff was a difficult one to fulfil. The greatest tact was necessary to avoid friction with one or other of the Powers and satisfy their respective demands for transport of men and material from place to place. Difficulties did at times arise, but strict impartiality and even-handed treatment to all comers was the rule adhered to, and when it was understood that there was no departure from it, things went smoothly enough. The station masters at the important stations were British officers selected for their linguistic qualifications and tact, and it was in a great measure due to their exertions that amity was so well maintained.

Each train was provided with a small native escort travelling in a third-class compartment, and the guards were men who had volunteered for the service, belonging to the Australian naval contingent in their naval kit. As the train drew up at the stations, the station guards of Indian troops fell in under their N.C.O. and remained at attention until it moved on. By these arrangements sufficient authority was displayed to stop irregularities and check disturbances.

The above is no mean record of services rendered by our officers and those under them to the Allied Powers and the civil community in North China, and is well deserving of a place in the Corps Annals, or even of wider dissemination.

Other R.E. officers in the meanwhile had not been idle ; in Pekin the various British officers had been connected up by telephone or telegraph, and the telegraph system between it and Tientsin under British management greatly improved by Brunner. At the Pekin terminus of the railway, near the Temple of Heaven, electric light was installed, the necessary plant being found in the Summer Palace. The Pei-ho River above and below Tientsin was cleared of obstructions, caused by sunken junks, and the landing stage at Sin-ho, the British seaport, was considerably enlarged and the commissariat stores and shed accommodation at that place added to. At Shan-hai-kwan a well-built pile-driven landing pier some 200 yards long was run out into deep water by the Kotla Sappers, giving access to the shore some time after the Pei-ho became frozen. A light railway brought out from India was laid from it to the cantonments 2 miles inland, and a gas generating station for the Balloon Section erected at Wei-hai-wei.

In January a Military Commission, all the Powers being represented, sat at Pekin under the presidency of Colonel Shone to consider and formulate proposals for placing the various Legation areas in a proper condition of defence and mutual support. Each having determined their limits, a combined scheme was drawn up. The British and Japanese elected to close in theirs with high substantial brick walls, loopholed, with flanking projections and gun emplacements at the salients. The others enclosed theirs by a combination of wall, earthen parapet, and ditch. The Tartar City wall 40′ high and 50′ wide

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at the top, closed in the whole to the south. A clear zone of from 100 to 150 yards wide was to be left outside each, and the Pekin railway station was to be brought up under, and outside the city wall, to the west of the Chien-Miu Gate, so as to be defended by the Legations. The perimeter of the British Legation having been decided upon, three R.E. officers under Major Dickie's orders were told off to the work of reconstruction and accommodation.

The area had been much extended beyond the old limits, and several large Imperial storehouses enclosed within it, which were adapted for the accommodation of the 250 British European troops to form the garrison. By means of a little ingenuity these buildings were made very suitable, considering the climatic conditions of cold in winter and heat in summer. The usual accessories, such as cook-houses, wash-houses, etc., were built and existing buildings adapted or built for officers' quarters, mess houses, storage accommodation for three months' supplies, a reserve of arms and ammunition, as well as hospital accommodation.

An immense amount of clearing away and rearranging of buildings had to be done within this area, together with draining and levelling for parade and recreation purposes—the garrison being practically confined within its limits, had to be given ample space to move about in.

A strong loopholed wall 12′ high was built on the north and west sides and provided with a musketry parapet all round, flanking projections, and gun emplacements. On the other two sides the British Legation joined up with the Japanese and the Russians, who continued the outer defences in accordance with the general plan agreed upon.

During the siege the Chinese had shown themselves adepts at mining, and it was therefore thought expedient to run countermine galleries well out at selected places, and this was carried out in the British Legation.

These operations were completed in time for the buildings to be handed over for occupation by the British Legation guard in the autumn of 1901 and, this accomplished, the Chinese Expeditionary Force ceased to be any longer in being. With the exception of a few troops to winter at Tientsin and Shan-hai-kwan, the rest were rapidly leaving for India, and the Engineers followed suit when the section of work for which each was responsible was cleared off, the stores disposed of and the accounts settled.

The survey party under Renny-Tailyour was actively engaged throughout the operations taking advantage of the various expeditions sent out from Pekin or Tientsin to map in as much of the country as could be commanded. Altogether 16,000 square miles of country were triangulated and 17,000 square miles of detailed survey on the $\frac{1}{2}$-inch scale completed with the plane table.

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Germany was the only other nation attempting any systematic survey of the country.

Although most of the fighting was over before the majority of the R.E. arrived upon the scene, there was an abundance of hard and varied work for them to tackle and get through. Whether our officers rose to the occasion and made the most of it must be left to others to judge. What has, however, been clearly brought out, in this and many other expeditions is, that our companies should not be over specialized in a particular branch of engineering, or they will not so readily be able to turn their hands to whatever work may confront them at the time.

Where *all* did well, and put their backs into their duties, it may seem ungracious to list the names of those who came prominently to notice, but there is this to be said, that as it is at the close of a campaign, after the usual special-action despatches have been submitted, that a better appreciation can be formed of the Engineer officer and his work, we may be permitted to give the names of those brought to the notice of the G.O.C. by the Colonel-on-the-Staff, R.E., at the close of the operations :—

Lieut.-Colonel G. K. Scott-Moncrieft, who from the first to last showed himself to be an excellent Engineer and invaluable officer.

Major and Brevet Lieut.-Colonel J. R. L. Macdonald, C.B., who carried out the onerous duties of Director of Railways under very trying circumstances with great success, but who, unfortunately, had to leave his post on account of ill-health.

Major J. E. Dickie, R.E., an officer of close and assiduous attention to his duties.

Major A. R. Reynolds, Brigade Major, who afforded willing assistance at all times.

Capt. R. P. Lee, upon whose shoulders the engineering work at the start rested, and who rendered valuable service.

Capt. P. G. Twining, an able railway engineer, through whose resourcefulness and energy the rolling stock of the broken-down railway was made able to meet a heavy strain of work.

Capt. R. E. Picton. This officer was Lieut.-Colonel Scott-Moncrieff's Adjutant from start to finish, and his right-hand man.

Lieut. S. G. Loch, of whom too much cannot be said in praise of his management of the British telegraph lines.

Lieut. H. D. Pearson, Orderly Officer, and a most hard-working, intelligent and promising officer.

Lieut. W. A. Stokes, graded as Staff Captain, and through whose energy and tact the Maler Kotla Sappers were admirably handled and worked.

Hon. Lieut. A. Watt, an officer of many excellent qualities who did admirable service.

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Also the following officers for good work :—

Lieut.-Colonel C. Penrose.
Major T. J. W. Prendergast.
„ C. A. R. Browne.
„ F. V. Jeffreys.
„ R. D. Petrie.
Capt. H. R. Stockley.
„ G. H. Griffith.
„ G. H. Boileau.
Lieut. H. F. E. Freeland.
„ E. C. Tylden-Pattenson.
„ H. E. C. Cowie.
„ E. W. S. Mahon.
„ M. R. Elles.

The following British warrant and non-commissioned officers and men :—

Conductor W. D. Gray, Adjutant-General's Department. This warrant officer was of the greatest possible assistance as head of the Brigadier-General R.E.'s Office.

Company Sergt.-Major T. J. Keenan, Madras Sappers and Miners, in independent charges did very good work for the telegraph.

Sergt. W. Tinkham, 4th Company, Bengal Sappers and Miners. A non-commissioned officer of much energy and resource.

Sergt. R. J. Sheridan, Military Works Services. This non-commissioned officer did exceptional hard and useful work in connection with the hutting of troops.

Sergt. W. Freshwater, Bengal Sappers and Miners, did excellent work for the telegraph.

Corpl. G. Watkins, 25th Company, R.E. An able, hard-working and efficient non-commissioned officer.

Corpl. A. Pitt, Somerset Light Infantry. A signaller for zeal and resource.

Corpl. G. Heywood, 3rd Battalion Rifle Brigade, for excellent work as a signaller at the Peking Headquarters Office.

22. The following warrant and non-commissioned officers and men for good work :—

Conductor W. Blain, Military Works Services.
Sergt.-Major Foreman of Works C. Shrapnell, R.E.
Company Sergt.-Major R. Snell, 4th Balloon Section.
„ „ J. H. Toy, 4th Company, Bengal S. and M.
„ „ H. Fisher, Mounted Sappers.
Sergt. F. H. Thomas, Military Works Services.
„ H. Edwards, „ „ „
„ M. H. Leonard, Litho. Section, Madras S. and M.
„ R. Bowery, 25th Company, R.E.
„ J. Ross, Litho. Section, Bombay S. and M.

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Sergt. J. Shedwell, Printing Section, Madras S. and M.
„ H. Withers, Telegraph Section, Bengal S. and M.
„ C. W. Rowe, 1/44th Company, R.E.
Farrier-Serjt. Hobbs, 4th Balloon Section, R.E.
Corpl. R. Wareham, 25th Company, R.E.
„ Welsh, „ „ „
Sergt. J. W. Elles, D.C.L.I.
„ C. Bailey, R.A.
Corpl. W. Scott, 1st Cameronians.
Lance-Corpl. G. D. Wilson, "The Queen's."
„ A. Wade, 1st Battalion Norfolk Regiment.
Private A. E. Webb, 3rd Battalion Rifle Brigade.
„ J. W. Mitchell, 1st D.C.L.I.
„ C. Cowlard, 1st Royal Scots Fusiliers.
„ W. Young, 1st Northampton Regiment.
„ A. Warnes, „ „ „
Sapper J. Tranter, 25th Company, R.E.
„ A. Elliott, „ „ „

23. The following native officers :—

Ansuf Ali Khan, Commandant, Maler Kotla Sappers. By his example and personal exertions he helped to keep up the *morale* of his company.

Subadar Mahomed Buksh Khan, Maler Kotla Sappers. This native officer helped along the work with great goodwill.

Subadar Krishnaji Gaekwar, Bombay Sappers and Miners, was of great service to his commanding officer.

Subadar Devasahayam, 3rd Company, Madras Sappers and Miners, carried out his duties very thoroughly.

Jamadar Krishna Appaji, Bombay Sappers and Miners. A very capable and zealous officer.

Subadar Jag Singh, 4th Company, Bengal Sappers and Miners, for good work.

25. The following native non-commissioned officers and men for good work :—

Havildar-Major Hyder Buksh Khan, Maler Kotla Sappers.
Havildar Gnanapragasem, Madras Sappers and Miners.
„ Mukhtesar Khan, Bengal „ „
„ Chinnasami, Madras „ „
Sapper Lazar, „ „ „

We cannot omit from this record the mention of the hearty co-operation which the United States Engineers, in the persons of Lieut. Stamford and others, gave on all occasions, nor were the Japanese—to mention Colonel Shiba and others—behind them in their readiness to join forces and assist in any way.

Although we had some things to impart to our neighbours, we had others to learn from them. For instance, the Americans and

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Japanese were ahead of us in field service telephones and telegraph; the Germans brought with them a very complete system of light railway and rolling stock, and a good pattern of portable hut; the Russians had a most excellent field kitchen; and so on. Those who kept their eyes open—and none were more apprehending than the all-seeing Japanese—could pick up many useful hints from their neighbours.

A digression from strictly engineering matters may perhaps be permitted, the occasion being exceptional, not only on account of the number of first-class Powers co-operating in a *casus belli*, but because the occasion was the first where our native troops, alone practically,—for only one British regiment and two British batteries were with our China expedition—were employed on Imperial service in conjunction with white troops other than our own.

Many were the conjectures as to the consequent effect this experiment would have upon the future bearing of our native troops towards ourselves, but the writer is satisfied that nothing but good came of their association with foreign troops. For one thing they were given a near view of the Russian—the much-talked-of Russki—and they found him to be an ordinary being, of no greater proportions or pretensions than anybody else, and they also could not help noticing that the troops of some Powers were not so well cared for by their officers as they themselves were by theirs.

The writer on one occasion was sketching in the grounds of the Summer Palace when a soldier of one of the Indian frontier regiments came up to him and enquired if he might look on. Taking a seat and entering into conversation he remarked in Hindustani "You know, Sir, we learn and understand more about many things in a week here than we could in a lifetime at home," and further added "Some day you will have to fight one of these European nations which are here, and when you do, don't leave us out, as you did in South Africa!" If such sentiments were to be found among our native troops in China, it was no false policy assuredly to place them in the field with the white troops of other Powers.

Further it must not be forgotten that in 1900—1901 the ill-feeling against us created by the Boer War was still prevalent, and showed occasionally in a manner not creditable to the troops of certain Powers, but although at times provoked, our native troops displayed tact and good temper, and held their own with commendable dignity.

It has been said with some degree of humour and a little sarcasm, that as a medal was not struck to commemorate the fighting combine of eight first-class Powers against China, some token at least should have been issued to inaugurate the fact that they did not fall out among themselves. Be this as it may none succeeded better than did the British Sappers in working in harmony with all with whom they came in contact.

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MOTOR CAR IGNITION SYSTEMS.

By Lieut. G. L. Hall, R.E.

The question of igniting the combustible mixture in the cylinder of a high speed petrol engine, such as is used at the present time for motor car and launch work, involves other considerations than are suggested for the stationary type of internal combustion engine. The difference between their requirements is mainly due to the fact that the stationary engine is normally a one-speed machine and rarely works with such a volatile fuel as petrol. The motor-car engine, on the other hand, runs at speeds varying over a considerable range, with average piston speeds greatly in excess of those commonly found in the stationary type.

In the early days of internal combustion engines, a form of magneto ignition was used, afterwards generally discarded for the more reliable hot tube. The latter was practically universal when the motor car appeared, with the natural result that it was used, in the form of a tube kept incandescent by a petrol or benzine burner, by practically all the pioneers of the motor industry. Its days were, however, numbered from the outset, as tube ignition in any form is quite unsuited to the work. Apart from the grave risk of fire, which was found to be very real in practice, it was wasteful of fuel and did not lend itself to variable timing; that is to say the charge was always fired at a fixed point in the stroke of the engine, irrespective of the speed at which it was running. It is obvious, from the nature of the case, that the time of ignition should be varied with the speed, in order to obtain the best results; the charge being fired early in the working stroke at high speeds, and later at low speeds. In fact, a range of some 30° to 45° is normally provided with the now universal electric ignition.

The firing of the charge electrically may be accomplished in two distinct ways, generally distinguished under the names of "high tension" and "low tension" ignition respectively. The original source of the electric energy required is either a battery—generally a secondary battery or accumulator—or a form of generator known as a magneto, which is simply a small dynamo whose magnetic field is produced by steel permanent magnets, instead of by the electro-magnets of its larger brother. It is usual, and will be convenient for the purpose of this article, to subdivide electric ignition into three main heads:—1. High tension battery. 2. High tension magneto. 3. Low tension magneto and battery. The first two depend on precisely similar

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electrical phenomena, their main difference in theory being that the first derives its energy from a battery, and the second from a magneto, or permanent magnet generator. The phenomena responsible for the action of the third type of ignition are very similar to those involved in the first two, but are manifested in a slightly different form.

High tension ignition, whether battery or magneto, depends for its action on electric induction. It is beyond the scope of this article to consider the theory of induction between adjacent conductors in any detail. Those to whom the principle is not familiar are referred to the various textbooks dealing with the subject, or are recommended to take certain facts for granted. Roughly speaking, the action is as follows :—A current is supplied from a battery or generated by a magneto at low pressure and passes round a closed circuit, known as the primary, back to the battery or magneto as the case may be. This primary circuit, part of which consists of a coil wound over an iron core, is periodically "broken," that is the current is suddenly interrupted, these interruptions corresponding with the firing strokes of the piston, and being effected mechanically by the rotation of the engine itself. Over the primary coil, on the iron core, is wound a second coil, electrically insulated from the primary but very close to it. The ends of this coil, known as the secondary, are connected to the sparking plug, the combination of the primary and secondary windings with the iron core forming the induction coil. The principle of its action is shortly this. Any alteration in the value of the primary current induces in the secondary winding an electrical pressure whose magnitude depends on the ratio of complete turns in the secondary to complete turns in the primary, and on the rate at which the necessary alteration in the value of the primary current is effected. The windings are so arranged as to produce a very high pressure in the secondary, which pressure is sufficient to force a small current across the spark gap inside the cylinder and so to fire the explosive mixture. For reasons which need not be investigated here, the maximum pressure is induced in the secondary when the primary circuit is *broken*, and the more rapidly this operation is effected, the higher will be the induced pressure. In practice, the interruption of the primary circuit is accomplished in two distinct ways, either by means of a cam operated by the engine, or electrically, by a device known as a trembler, which is precisely similar in its action to the striker of the ordinary electric trembling bell. The two systems are commonly known as the "trembler," and "non-trembler" or simple make and break.

1. *High Tension—Battery and Coil.*—In *Fig.* 1 (see *Plate*) is shown diagrammatically the simplest form of high tension battery ignition circuit for a single cylinder. For the sake of clearness, the primary and secondary windings are shown separately, though in fact the latter is wound over the former. The iron core has also been omitted.

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In all ignition systems, to simplify the wiring, use is made of earth returns, that is the frame and engine are used to convey the current back to the battery and coil. These earth connections are shown by the symbol E, and the path of the current through the metal work of the car is further indicated in *Fig.* 1 by dotted lines. The coil shown is of the simple make and break or non trembler type. The battery consists of two secondary cells connected in series, made up in one casing, giving a pressure of about 4 volts. The current leaving the positive plate of one cell passes through the primary coil to the fixed contact C, through the spring S which has been pushed into contact with C by the cam K. From S it returns to the battery by the frame of the car. The contact breaker is rotated in the direction of the arrow by suitable gearing from the engine, so arranged that the cam K will allow the spring S to leave the contact C, and so interrupt the primary circuit, at fixed periods corresponding to the firing strokes of the engine ; that is, at every other revolution of the crank shaft.

At the moment when the cam K allows S to leave the contact C a high electrical pressure is induced in the secondary winding of the coil, owing, as mentioned above, to the sudden interruption of the primary current. This forces a current in the form of a spark across the sparking plug gap, the secondary circuit being completed through the metal of the engine and frame. Provided the contact breaker is correctly set in relation to the crank shaft, this spark will occur at the right moment to fire the mixture.

It will be noticed in *Fig.* 1 that a piece of apparatus called a condenser is connected across the primary make and break. The action of this condenser is so important, and so little generally understood, that it will be worth while examining it in some detail. Its function is chiefly to suppress as rapidly as possible the primary current at the moment of break. An electric current when flowing in a circuit resents being suddenly stopped, in much the same way as moving matter ; a revolving fly wheel, for instance. In consequence, unless steps are taken to prevent it, a small arc or flame will form between C and S, as soon as they are separated by the action of the cam K, owing to the electrical momentum of the primary current. This arc is injurious for two reasons. Firstly, it will rapidly burn away the platinum contacts on C and S. Secondly, the very fact that an arc forms across the contacts means that after the theoretical moment of break the current is still flowing in the primary, and will therefore die away comparatively slowly. Since the intensity of induction in the secondary depends on the suddenness with which the primary current is interrupted, it is obvious that this arc at the contact breaker will react injuriously on the spark at the sparking plug, which may even fail altogether. It therefore becomes of primary importance to suppress the arc at the moment of break, and so ensure the instantaneous cessation of the primary current. The

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extinguishing of the arc could, in fact, be accomplished in other ways than by the introduction of a condenser; by some form of magnetic blow-out for instance, as is used for a similar purpose in tram and railway controllers. But besides effecting this primary object, the condenser fulfils another very valuable function which will be explained later.

The condenser consists essentially of sheets of tin foil and paper interleaved, alternate tin foil sheets being connected to each side of the break. The arrangement is indicated by the conventional sign in *Fig.* 1. At the moment of break between C and S, a rush of current flows *into* the condenser, *through* which there is no path. The behaviour of the apparatus under this rush of current is closely comparable to that of a spring when struck by a hammer. As soon as it is charged by the rush of current, it will at once expel its charge, sending a current through the primary in the opposite direction, against the battery pressure, so tending to demagnetize the core; just as a spring will rebound after a blow and throw the hammer away from it.

This action and reaction continues in the form of an oscillatory discharge from the condenser until the primary magnetizing current is brought to rest. *Fig.* 2 shows the nature of the action, the initial charge by the magnetizing current being shown by the vertical line on the left of the diagram, and the subsequent oscillations by the wave lines. The total time occupied in suppressing the primary current is extremely short, the oscillations having a very high frequency.

The oscillatory nature of the condenser discharge naturally leads us to its second important function, which is to produce a stream of sparks at the sparking plug every time the circuit is interrupted by the contact breaker. Since a pressure is induced in the secondary by every change in the value of the primary current, such a pressure will be produced by the oscillatory current from the condenser, the oscillations being so rapid as to cause a spark at the plug corresponding to each change of direction of current in the primary circuit.

The trembler type of coil is very similar in its action to the one described above, the main difference being that the actual interruption of the primary current is effected magnetically instead of mechanically. A diagram of connections for a trembler coil is given in *Fig.* 3, the trembler being shown in detail in *Fig.* 4. The contact maker, driven by the engine, consists in this case of an insulated fibre disc, in which is embedded a brass segment, the latter being in electrical connection with the metal work of the car. Rubbing on this fibre disc is a metal brush, usually in the form of a roller, insulated from the frame of the car and connected to one end of both primary and secondary windings. This metal brush completes the primary circuit at periods corresponding to the engine firing strokes, such a state of affairs being shown in the diagram (*Fig.* 3). The magnetic make and break, or trembler, consists of a hinged arm T normally held against the contact

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C by the spring S. Attached to T is a piece of soft iron K. The current flows from the battery to C, then to T, round the primary coil to the contact maker and so back by earth to the battery. This current at once magnetizes the core, which attracts the iron piece K, and so pulls T away from the contact C, against the action of the spring S; with the result that the primary circuit is broken and a pressure is induced in the secondary as before. The instant that this occurs, however, the core loses its magnetism, and the spring S forces the arm T into contact with C, so that the process starts again. The result is a rapid vibration of the arm T; the circuit being interrupted a large number of times while the brush is making contact with the segment; and is manifested by the characteristic buzz of the trembler. This arrangement ensures a rapid break, and results in a considerable economy of current, since the time during which the primary circuit is closed is reduced to a minimum. A condenser is, as usual, connected across the primary break, that is the arm T and the contact C, as shewn in *Figs.* 3 and 4. The secondary circuit is completed by way of the sparking plug, and the metal work of the engine and frame.

So far we have considered the case of the single-cylinder engine. With two or more cylinders, the problem becomes more complex, owing to the difficulty of synchronizing the ignition, and so ensuring that each engine shall bear its proper proportion of the total load. A very general arrangement which is perhaps the most obvious one is to have a separate induction coil for each cylinder. Practically all car engines nowadays using battery ignition have the trembler type of coil, which is more satisfactory in practice, and naturally shows a more marked economy in current as the number of cylinders increases. Multi-cylinder ignition systems using one coil per cylinder are capable of subdivision into two types, firstly those having a separate trembler with each coil, and secondly those having a single trembler, which actuates each coil in turn. It will be convenient to consider throughout a 4-cylinder type of motor, the arrangement of wiring, gearing, etc., being easily deducible therefrom for the case of two, three, or six cylinders. In the case of a 4-cylinder engine having one coil and trembler per cylinder, the revolving contact maker has four segments, which are in connection with their respective coils, so that the contact maker will, as in the case of the single cylinder, be revolved at half crankshaft speed. A type of contact maker for four cylinders is shown in *Fig.* 5. This arrangement is a very common one, but the four tremblers require careful adjustment so as to ensure proper synchronism. A trembler which is set close, *i.e.* with the contacts nearly touching, will fire the charge earlier than one which is set wide.

The second type,—the four coils and single trembler—on the Wilson-Pilcher system, is shown in *Fig.* 6. The trembler blade is actuated, not by the core of a coil, but by a small separate electro-magnet, a

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combination known as an auto-trembler. The trembler is placed in series with each coil in turn, the primary windings of the latter being connected as shown in the diagram. This does away with any synchronizing difficulties, since the same trembler actuates each coil in turn.

A third arrangement is also used with multi-cylinder engines. This is known as high tension distribution, and is the system used with the majority of high tension magnetos, as will be seen later. A diagram is given in *Fig.* 7. A single coil and trembler is used, the high tension current being fed to each sparking plug in turn by way of the high tension distributor, which is similar in principle to the low tension contact maker, but requires very much more careful insulation owing to the high electrical pressure in the secondary at the moment of induction. It is desirable to have a second trembler in reserve.

Before passing to the subject of magneto ignition, some mention may be made of the Lodge coil, an apparatus which has been in use for some time on large stationary gas engines, but has only lately been adapted to motor-car purposes. To go fully into the theory of the Lodge coil would involve a good deal of space and many technicalities, but a rough idea of its action may be of interest. Up to a certain point, as will be seen from *Fig.* 8, the apparatus is an ordinary induction coil. The ends of the high tension winding are taken to two points *a*, *a*, across which is connected the spark gap A. The points *a*, *a* are also connected to the inner surfaces of a pair of Leyden jars, which are, in effect, special forms of condensers, the inner and outer surfaces corresponding to the interleaved sheets of the ordinary flat condenser. The two outer surfaces are connected, by way of the usual high tension distributor, to the spark gaps B. These latter are the cylinder sparking plugs. Pressure is induced in the high tension winding, as usual, at the moment of primary break. A charging current flows to the inner surfaces of the Leyden jars, and at once, as before explained, recoils and discharges across the gap A. This spark takes place in a tube forming part of the coil apparatus. At the instant of the A discharge, the outer surfaces of the jars discharge with extreme rapidity across the gap B, thus firing the charge. The high resistance path L is provided to enable the outer surfaces of the jars to receive the requisite charge.

Without going deeply into the theory of these B discharges, a few words on the subject may be of interest, as it has an important bearing on the practical application of the coil. The nature of the B spark is oscillatory, the oscillations being of enormous frequency. A property of such discharges, as exemplified by lightning, is that the high resistance of an air gap, such as exists at B, offers an obstruction to their flow which is almost negligible compared to their disinclination to take an indirect path, such as would, for instance, be provided by a badly insulated sparking plug. In popular

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language, it may be said that these rapidly oscillating discharges have no time to consider the path of lowest ohmic resistance, but will preferably take the most direct route. This property is of great practical importance for motor-car ignition, since faulty insulation, sooted sparking plugs, and the like have no appreciable effect on the quality of the spark.

2. *High Tension Magnetos.*—The many diseases to which secondary batteries are prone, as well as the trouble of providing for their necessary periodical recharge, led to the introduction of magneto ignition for motor-car engines. Low tension magnetos, largely used for stationary work, and whose principle will be explained later, were at first very generally employed, but have to-day almost entirely given way to the high tension type. The high tension magneto, for which a typical circuit diagram is given in *Fig.* 9, consists of two essential parts, the field magnet system and the armature, which generally revolves inside the crescent-shaped pole pieces of the field magnet. Wound on this armature, which is constructed of soft iron and is usually laminated for technical reasons which conduce to a higher efficiency, are two coils, corresponding to, and fulfilling the same duties as the primary and secondary windings of an induction coil. The armature is revolved inside the field magnet system by the engine. The ends of the primary armature winding are connected to a closed circuit, by way of the primary contact breaker, earth returns being used for convenience as in the case of battery and coil. The ignition is switched off, as shown in *Fig.* 9, by permanently connecting the armature winding to earth, so that the contact maker does not interrupt the primary circuit.

A current is generated in the primary winding by the rotation of the armature on the well-known dynamo principle, and takes the form shown in *Fig.* 10, being zero when the winding lies along the magnetic field, and a maximum when it lies across the field (*Fig.* 11).* The direction of the current is naturally reversed as the armature revolves, since the winding first moves across the magnetic field from top to bottom and then from bottom to top. The result is that an alternating current is produced having two maximum values one positive and the other negative, for each complete revolution of the armature. The contact breaker is arranged to break the primary circuit at each maximum current value, that is twice every armature revolution, as shown in *Fig.* 9. This interruption of the primary current induces in the secondary, or high tension winding, a pressure sufficient to force a current across the sparking plug gap, the double wound armature acting in precisely the same way as an induction coil. A safety spark gap is provided in the secondary circuit to prevent strain on the insulation in case of a failure of the spark at

* This figure shows the theoretical positions. The actual positions of the armature at the moments of zero and maximum current are about 20° beyond the theoretical, in the direction of rotation.

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a plug. With regard to constructional details, these of course vary with the particular make of machine. Magnetos of the type under consideration,—the Bosch, Simms, Nilmelior, and many others are similar in their general arrangement. One end of the primary is connected to the armature core and thence to earth by way of a rubbing contact or brush. The other end of the primary is connected to the insulated portion of the contact breaker, the earthed contact of which normally completes the circuit. To this end of the primary is connected one end of the secondary, an arrangement generally adopted for practical reasons in these double-wound armatures as well as in ignition induction coils. The other end of the secondary is connected to a slip ring, from which the high tension current is collected by a brush and fed to the revolving portion of the high tension distributor by a second brush. The revolving part of this distributor carries a third brush which delivers the high tension current to the various cylinders in turn.

The primary contact breaker is mounted on the armature spindle and takes various forms, the Simms and Bosch types being illustrated in *Fig.* 12. In the case of a 4-cylinder engine, the magneto is driven at crank-shaft speed, the contact breaker being arranged to break the circuit twice every revolution, there being of course two firing strokes during this period. The high tension distributor is driven through a 2 to 1 gear from the armature spindle, so that the distributing brush passes two contacts per revolution. A condenser is arranged, as with battery ignition, across the primary break, and fitted as a rule in prolongation of the armature core. A sectional diagram is given in *Fig.* 13, showing the arrangement of a high tension magneto of this type.

The question of varying the timing of the ignition is not so straightforward as with the battery system. *Fig.* 10 makes it clear that the period of maximum current is very short, and it is obvious that only one position of the timing lever will give a primary break at its theoretically correct position, that is, at the moment of maximum primary current. The greater number of magnetos are provided with a variable timing gear which merely alters the moment of primary break, (*v. Fig.* 12), it being generally arranged that this break shall synchronize with maximum armature current when the ignition is retarded, or nearly so. This facilitates starting; and, although, as the timing is advanced, the break must necessarily take place when the current is not at its maximum, yet, since the engine will now be running faster and the magneto will therefore be generating a higher average current, the arrangement is to a certain extent self-regulating. Provision is made, however, in some types to ensure that the break shall always occur at the point of maximum current. This is usually done by revolving the field magnets through the same angle as the contact breaker, and has the effect of

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moving the current curve along, so that the peaks always correspond with the moment of break. To this type belong the Gianoli and the Mea, the pole shoes only being moved in the former type, and the whole magnet, which is cup-shaped, in the latter.

A large number of modifications of what has been taken as a standard type exist. In the Simms-Bosch revolving shield magneto the field magnets and the armature are both stationary, but the magnetic field is forced to move by the rotation of a shield between the armature and the pole shoes, the arrangement being shown in *Fig.* 14. This has the effect of producing an alternating current which reaches a maximum value *four* times per revolution, corresponding with the four positions of the revolving shield aa', bb', $a'a$ and $b'b$. No gearing is therefore required for the high tension distributor and the contact breaker, both of which are mounted to revolve with the shield, the contact breaker being arranged to interrupt the primary circuit four times for each revolution of the shield, which is driven at half crank-shaft speed.

The Nieuport magneto also aims at abolishing the 2 to 1 gear by the arrangement shown in *Fig.* 15. The two ends of the secondary are connected to segments embedded in fibre discs, keyed side by side on the armature spindle. For clearness these are shown of different diameters in *Fig.* 15, but are in fact the same size. Two brushes are arranged at opposite sides of each fibre disc and distribute the high tension current to the plugs, as the revolving segments reach them. This results in two simultaneous sparks in series, one of which is used to fire the mixture, the other taking place in the cylinder which has just completed its exhaust stroke, where it does no harm. The high tension circuit is completed as follows: from one end of the high tension winding to segment *a*, from *a* to brush *b*, from *b* to plug *c*, from *c* to earth, from earth to plug *d*, from *d* to brush *e*, and so to the other end of the coil by the segment *f*.

The principle of connecting the ends of the secondary winding to two sparking plugs in series is also adopted in the dual ignition type of magneto. In this case, the two sparks are produced in the same cylinder, with the idea of ensuring the more rapid combustion of the charge and of facilitating starting.

A form of magneto ignition known as the single winding, or separate coil, type enjoyed considerable popularity a short time ago, but seems at present to be giving way to the double-wound type. With this system the armature has only one, a low tension, winding—the current generated being supplied to an induction coil of the ordinary type. This arrangement has two distinct advantages. Firstly it is easier to ensure satisfactory insulation for the high tension winding, where the latter is not subjected to the mechanical strains set up by the rapid rotation of the armature, and secondly, it lends itself well to alternative battery ignition. The magneto is generally geared,

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just as in the double-wound armature type, to run at crank-shaft speed (in the case of a 4-cylinder engine) and the current is interrupted at the two maximum points.

The separate coil magneto may also be arranged to run without gearing, in conjunction with a trembler coil; so that it requires no setting with reference to the engine. The magneto can in this case be driven by a belt or friction wheel, generally at a considerably higher speed than the engine. The contact maker is operated by the engine, as usual, at every firing stroke irrespective of the value of the current generated by the magneto. Since the latter runs at such a high speed, the time during which the brush is closing the primary circuit will be long enough to ensure that at some point in the period of primary contact, the magneto current will reach its maximum value. This is the system on which the Rankin-Kennedy magneto works, the circuits being exactly similar to the Wilson-Pilcher already described (*Fig.* 6), a magneto being substituted for the battery. A very similar arrangement is used in the Ford cars, except that the magneto is a multipolar machine running at crank-shaft speed, which is electrically equivalent to an ordinary 2-pole magneto driven at a higher speed.

3. *Low Tension Magneto and Battery.*—This form of ignition, although nearly obsolete for car work, is often found in small launch engines, particularly in those of American make. Mention has already been made when considering the action of the condenser, of the tendency of an electric current to continue flowing, in the form of an arc across the contacts, for a short time after the circuit has been broken. This electrical momentum is more marked in a circuit, part of which is wound as a coil, particularly when the centre of this coil is filled with an iron core. Use is made of this phenomenon in the low tension type of ignition where the break is arranged to take place inside the cylinder, the resulting arc being used to ignite the mixture. The necessary coil and iron core is provided by the winding on the magneto armature. The arrangement is simple, and involves no elaborately insulated high tension circuit, but possesses the obvious disadvantage of a mechanically operated moving contact inside the cylinder. It is also harder to start the engine than with the high tension system, since only a poor arc is produced until the magneto has obtained a fair speed. For this reason, an auxiliary starting battery is frequently fitted. A low tension battery and magneto circuit are shown in *Fig.* 16. The battery in this case is usually of the primary type, working at about 6 volts. It will be noticed that a coil with core, generally known as a self-induction coil, forms part of the battery circuit, in order to increase the value of the arc, which is further improved by breaking the circuit as rapidly as possible. This is done by striking the contacts apart by the action of a spring, which is released by a cam gear driven from the engine.

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MEMOIR.

LIEUT.-COLONEL THE RT. HON. SIR FLEETWOOD ISHAM EDWARDS, G.C.V.O., K.C.B., I.S.O., ROYAL ENGINEERS.

By General Sir Richard Harrison, G.C.B., C.M.G., late R.E., Col. Com.

When Lord Palmerston was our Foreign Minister, he often required confidential work done that necessitated special knowledge and peculiar training on the part of those who had to carry it out. In such cases he frequently went to Sir John Burgoyne, the Head of the Royal Engineers, to obtain from him the loan of an officer. This custom he found so satisfactory that at one of his conferences with Sir John he is reported to have remarked "if I wanted an officer to fill the high appointment of Archbishop of Canterbury I expect you could supply one."

The subject of this brief Memoir furnishes one of several notable examples of how the training received by the Royal Engineers fits them not only for their own immediate business, but also for almost any career when knowledge and industry are combined with tact and modesty.

Fleetwood Isham Edwards, who was born April 21st, 1842, was the second son of Mr. Thomas Edwards, of Woodside, Harrow-on-the-Hill, and his wife Hester, daughter of the Rev. William Wilson, of Knowle Hall, in Warwickshire.

He began his school life at Uppingham, under Dr. Thring, and thence went to Harrow. He entered in the third remove of the "Shell," at Easter, 1855, being then barely 13 years old, and reached the second remove of the fifth in December, 1858. After some months' special preparation with an Army tutor at Tunbridge Wells, he passed an open competitive examination for admission into the Royal Military Academy at Woolwich. While at Harrow he had taken part in the games for which that school is famous; rackets, cricket, and football. In the two former he would no doubt have distinguished himself at the school, had he not left earlier than usual to enter the Army. In after years he was elected a

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member of the "Zingari" Club and took part in many county and regimental matches.

While Fleetwood Edwards was at Harrow the Head Master was the Rev. C. J. Vaughan, who afterwards became Master of the Temple, and then Dean of Llandaff. Vaughan was in January, 1860, succeeded in the Head Mastership by Butler, who afterwards was appointed Master of Trinity College, Cambridge. Dr. Butler, who all his life took the keenest interest in Harrow, wrote in 1910 to Lady Edwards "your dear husband and Lord Spencer were among the very best Harrow men of my time. It was always a real pleasure to me to shake hands, and have a few words with him at the meetings of the Governors of Wellington College. I had watched his distinguished career with pride and admiration, knowing that his fine character must make him loved and trusted whether in office or in retirement."

After a short leave, spent in getting his outfit and making preparation for his new life, Edwards joined with the rest of his batch at Addiscombe. They were sent there, as a temporary measure, because all the available room at the Woolwich Academy was required for Addiscombe cadets who were gazetted to the Imperial list, the old East India Company and its separate army having been abolished. Six months afterwards, Addiscombe was finally closed, and all who were there were sent on to Woolwich.

After passing through the necessary probation, Edwards was appointed Senior Under-Officer at the Academy. This appointment was always considered a high honour and was much coveted, notwithstanding the nickname given by the cadets to those who held it, of "Golden Images," because of the amount of gold lace with which their tunics were adorned. Cadets who served with Edwards at the "Shop," as it is called in familiar language, all bear testimony to his character at that time. He was said to be "a delightful companion, good at all sorts of games and drills, very popular with all classes of cadets; but in whatever company he found himself, he never flinched a hair's breadth from the high ideals of the noble life he had set himself to follow, and which he steadfastly pursued."

On the 30th June, 1863, he obtained a Commission as Lieutenant in the Royal Engineers. He was tenth of a batch which supplied 12 to the Corps he joined, and 31 to the Sister Service, the Royal Artillery.

His first station was the School of Military Engineering at Brompton Barracks, Chatham. Here, with those who were commissioned at the same time, he learned the duties and responsibilities of an officer in the Army, and was put through the special courses taught there, viz.: Fieldworks, surveying, and building construction, etc. Here too I first met him. I was his senior by some eight years in the Army, and I was a Staff officer while he was under instruction. But

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this made no difference in our friendship. We were drawn together by having been at the same school, and by our association in the same games. While we were together, I took him to my home near Maidstone, and also accompanied him to other places in the neighbourhood, at one of which he met the young lady who afterwards became his wife.

In his last year at Chatham he became captain of the R.E. Cricket Eleven. He is described by one* of his own "batch" as "an ideal captain, a good player, patient with his team which he handled with great tact and good judgment."

In this description I fully concur. I fancy I see him now, in his trim cricket dress, standing at his favourite position in the field, with eyes intent on the batsman, and hands ready to pick up with the greatest rapidity the swiftly-moving ball; or walking slowly back to the Pavilion after a successful innings in which, from start to finish, his bat had been kept scrupulously *straight*, worked by a cool head, and a firm yet supple arm. We used to notice that, the better the bowling, the greater seemed to be his power of resisting it. Should the tide of victory seem to be turning against us, he would take all the more pains to at least secure an honourable defeat.

I wonder if those who in after years were anxious to secure him for some Staff or other appointment took account of the qualities he displayed in the cricket field, believing that those qualities would ensure his success in the sterner duties of life? If so they were not far wrong. I could call to mind many instances to show how boys and young men who were good at games were also good at work. This was particularly so in the case of the subject of this Memoir.

On the completion of his course of instruction at the School of Military Engineering, Edwards was sent to do duty at the fortress of Dover.

His educational life at Harrow, Addiscombe, and Woolwich, and finally at Chatham, had been quietly but satisfactorily passed through, and now he was going forth at the age of 23 to take his place in the Army of his Queen, and to make practical trial of the knowledge that he had acquired, and of the character that he had gained.

At Dover he was set to do the ordinary duty of a young officer of Royal Engineers at a garrison station, viz.: the repair and renewal of the fortifications and the repair of barracks. He also took his share with those of other corps in the ordinary garrison duties, which consisted of boards, courts-martial and so on. No doubt, now and then he joined in a game of cricket, or had a sail on the uncertain waters of the English Channel; those waters which, as he soon realized in his study of fortification, take a prominent part in the defence of the

* Colonel Todd, R.E.

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British Isles, and have up till now enabled this Nation to retain the proud boast of Mistress of the Seas.

After little more than a year at Dover, he was selected to be the Private Secretary and Aide-de-Camp of General Sir Frederick Chapman, Governor of Bermuda. He accompanied his Chief to that island and remained with him for over two years. An officer* of the Gloucester Regiment who at that time was stationed in Bermuda writes of him as follows : "Fleetwood Edwards came out to Bermuda in 1867 as A.D.C. to the Governor. He had then the same fascinating manner and presence that he retained through his life. We all thought him delightful, so extraordinarily tactful and thoughtful, and withal so cheery and amusing. In the Bermuda society of those days he was worth anything to the Governor and Lady Chapman, and all the islanders were devoted to him. Without in the smallest degree attempting to preach to one, he exercised a great influence for good on his friends at all times. I believe him to have been a truly religious man in the most unostentatious way. Of all people I have known, I think he retained the freshness and charm of his youth longer than anyone. Whenever I came across him at 'Court he was the same genial light-hearted comrade ; and I invariably felt, however long a time elapsed between our meetings—often some years —that we began again exactly as we left off."

From Bermuda, Edwards returned home in the summer of 1869, and was quartered for a year in Ireland in charge of the Fermoy district. He then received the special appointment of Assistant Inspector of Works at the Royal Arsenal, Woolwich. While here (in 1871) he married Edith, daughter of the Rev. Allan Smith-Masters, of Camer, Kent. But she died two years afterwards.

While Edwards was at the Arsenal the office of Inspector of Works was held by Major Scratchley, R.E., who later on became Governor of New Guinea, and was knighted. At that time the manufacturing and store departments were under the Surveyor-General of the Ordnance, a political administrator at the War Office. But the department of works of which Scratchley was the head was under the Inspector-General of Fortifications. The business that it had to do was to carry out all the building work at the great Government manufactory, where naval and military guns and carriages were designed and constructed, and where Army stores of every description were kept in charge. Just about this time the Naval Dockyard, which formerly was used for the construction of ships of war, was handed over to the Army. The alterations necessitated by this change were carried out by the works branch at the arsenal. The same branch had to superintend laying the foundations

* Lieut. Henry Tomkinson who in after years was transferred to the Royal Dragoons and became colonel of that distinguished regiment.

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of the great steam hammer invented by Mr. Nasmyth, which brought about quite a revolution in heavy gun construction. Then piers had to be thrust out into the river to enable the iron vessels, which were fast succeeding wooden ones in our naval and mercantile service, to come alongside and discharge their cargoes. Shops for carpenters and smiths had to be built with up-to-date fittings, and railways had to be laid down to meet the traffic that increased in bulk and weight every day. With all this work in hand, a conscientious officer like Edwards must have found plenty to do. The occupation was what an officer of Royal Engineers was trained for, and, as far as I can gather, he did his share of it with zeal and credit. But it must have been somewhat strange to him after his experience as Aide-de-Camp to the Governor of Bermuda; and, when he was asked by Sir Lintorn Simmons the newly appointed Inspector-General of Fortifications, to take a similar place on his Staff, I can well imagine that he was quite content to accept the offer.

On August 2nd, 1875, Fleetwood Edwards went with his new Chief to call on the various authorities at the War Office: H.R.H. the Duke of Cambridge, Commander-in-Chief of the Army, Mr. Hardy, Secretary-of-State for War, Lord Eustace Cecil, Surveyor-General of the Ordnance, and others. By the middle of the month he had settled into his new position, his lodging in Jermyn Street, and his club (the Senior United Service) being quite close to his work at the Horse Guards. His appointment entailed much more work than usually falls to the lot of an aide-de-camp. The Inspector-General of Fortifications was head of the Corps of Royal Engineers, and was responsible not only for the proper training and efficiency for war of their officers, N.C. officers, and men; but also for the carrying out of the work on which, in addition to their military exercises, they were employed in time of peace. All the fortifications throughout the Empire were in his charge. He had to take steps to keep those that existed in proper repair, and he had also to bring forward for consideration such renewals and improvements as the constantly changing pattern of the arms in use among the military nations of the world rendered necessary. In order to carry this out thoroughly he had to make careful enquiry regarding any new military machines that put in an appearance, such as electric telegraphs, electric lights, submarine mines, railways, motors, and flying machines. He also had to make practical trials of those that seemed as if they had come to stay. Moreover he superintended the department that existed for the repair and renewal of barracks, and for the construction of new ones when funds were allotted for the purpose. Naturally the A.D.C. of an officer with so large a charge held no sinecure. He had to be very regular in his attendance, very methodical in his habits, and to keep himself sufficiently "primed" in regard to the many technical

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and other subjects with which his Chief dealt, to be able to give an intelligent opinion when asked to do so.

For three years from 1875 to 1878, sometimes travelling with his Chief to inspect men and forts, and for longer periods conducting the office work in London in the light gained by those inspections, Edwards continued to lead an active but uneventful life. How he carried out his duties during that period can be gathered from a letter of which the following is an extract written to him by Sir Lintorn Simmons in the autumn of 1878 when he was leaving to take up other work.

"11*th September*, 1878.

"MY DEAR EDWARDS,

"It has been a great source of grief to me for some time past to know that it was probable I might soon lose you as my A.D.C. in which capacity I can truly say you have given me unalloyed satisfaction. The pain of losing you however is not unaccompanied with pleasure that you have been selected for such an honourable and responsible position as equerry, and therefore companion to a young Prince, who must be influenced by any person holding such a position for good or for evil. Looking to the great national importance of our Princes being surrounded with good influence, and having such entire confidence in you, I am glad, as an Englishman, and a subject of the Queen, that the selection has fallen upon you, but I must not allow you to imagine that I made it. Your name had been mentioned to the Queen by some other friend before I was consulted on the subject, and I then could only state what I thought of you, and express my willingness, but not without sincere regret, to place you at H.M.'s and the Prince's disposal, so that you owe your selection to your own good qualities and not to me."

But in the summer of that year, before he left the War Office, he was sent with his Chief to take part in the celebrated Congress of Berlin. This led to his making friends with the chief British representative at that Conference, and eventually brought about the appointment alluded to in Sir Lintorn Simmons' letter, viz.: Equerry to Prince Leopold.

In order to show how it came about that Simmons (with his A.D.C.) took part in the Berlin Congress I must briefly recall to mind the time when he first gained his knowledge of the "near East." It was in the autumn of 1858. He was then a junior captain of Royal Engineers, employed as Secretary for Railways at the Board of Trade, but on leave for a few weeks, with permission to travel in eastern Europe. He happened to be at Constantinople when war broke out between Russia and Turkey, and he immediately went to the Embassy and offered his services to Lord Stratford de Redcliffe who was then Ambassador there. Recognizing that such service might be of great value, Lord Stratford requested Capt. Simmons to proceed to the Danube and report on the defences of the Turkish frontier, and the condition of the Ottoman

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Army that had been sent by the Sultan under the command of Omar Pasha, to resist the Russian advance. This duty having been carried out satisfactorily, Lord Stratford then requested Simmons to inspect the defences of the Bosphorus. After that he was directed to accompany Admiral Sir Edmund Lyons to the Black Sea, and report on the state of defence of Trebizond, Batoum, and other Turkish ports. His leave having by this time expired, Simmons was preparing to return to England, when intelligence was received that the Russian forces were about to cross the Danube near Galatz, and he was requested by the Ambassador to find his way as quickly as possible to Omar Pasha, and inform him of the position. Proceeding at once to Varna, Simmons rode to Schumla, and thence to Tertuchan, arriving in time to save the Turkish corps at Galatz from being cut off. From that time, throwing up his peace appointment at the English Board of Trade, he became attached to the great Turkish general, Omar Pasha, and remained with him throughout the war, becoming eventually British Commissioner with the Turkish Army. In February, 1854, France and England joined with Turkey against the Russians.

How Simmons took part in the defence of Silistria, and the crossing of the Danube by the Turkish Army, and how eventually he accompanied Omar Pasha to the Crimea, and then to Mingrelia, it is not our immediate business to relate. I only mention the facts to show the unusual opportunities that he had of studying the Eastern question in a thoroughly practical manner. It can well be understood how it was that, when Lord Beaconsfield took up that question during the Russo-Turkish War of 1876-77, and looked about for an expert to give him sound geographical and military advice, he found one in Simmons.

In January, 1878, notwithstanding a world-renowned defence by the Turks against their Northern foe at Plevna, the Russians crossed the Balkans, and were with their advanced troops almost in sight of the capital, when the Beaconsfield Ministry ordered the Mediterranean fleet to steam through the Dardanelles and anchor near Constantinople. For a time war between England and Russia seemed inevitable. Lord Beaconsfield proposed a large vote of credit for warlike preparations. The reserves were called out, and native Indian troops were brought to Malta. Meantime, in order to save his palace, the Sultan appeared ready to agree to Russia's demands, and probably would have done so had not Great Britain intervened, and demanded that the terms of peace should be submitted to a Congress of the Powers, meeting at Berlin.

To this Congress Lord Beaconsfield and Lord Salisbury went as the representatives of Great Britain. General Sir Lintorn Simmons was selected to act as military adviser to the British Commissioners, and he was accompanied by Capt. Ardagh, R.E., and Capt. Edwards, A.D.C. When the Congress assembled Edwards found that the Prime

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Minister's Private Secretary, Montagu Corry (afterwards Lord Rowton), was an old Harrow contemporary and friend. This, and their association in the work of the Congress, and the fact that their natures were similar and altogether congenial, drew the two young men very much together. When the work of the Congress was over, the British representatives came home to England together and an enthusiastic reception was accorded, by the public, to Lord Beaconsfield, when they arrived at Dover.

As soon as possible, after their return, Lord Beaconsfield, accompanied by his Private Secretary, went to see the Queen at Osborne. It was probably during this visit that the question arose of the appointment of Fleetwood Edwards as Equerry to Prince Leopold. Evidently when, a few days later, Sir Lintorn Simmons' "command" to Osborne, on return from Berlin, included his Aide-de-Camp, it was with the intention that the latter should be seen by the gracious Lady on whom eventually it would rest to make the appointment. An extract from a letter written by Sir Henry, elder brother of "Charlie" Gordon, who was for many years the well-known head of the Military Store Department at Woolwich, will come in appropriately here.

"*October* 24th.

"My Dear Edwards,

"When I saw your name among the visitors at Balmoral, I said at once to my wife that you were going to be a joint assistant to Privy Purse with Pickard. I then heard it was to be an Equerry to Prince Leopold. Whichever it may be—perhaps both—be assured no one among your hosts of friends can be more delighted than myself at your good luck, and I know no one, high or low, who is so perfectly fitted to fill such an office. Urbanity of manner, combined with intelligence and zeal of no ordinary nature, are gifts that are possessed by few. You are one of them, and I wish you very heartily success."

Directly after the visit to Osborne with Sir Lintorn Simmons, Edwards was offered the appointment of Equerry to Prince Leopold (afterwards Duke of Albany). But, before he had time to fit himself out with the necessary uniform, he received a telegram from Colonel Pickard telling him not to do so for a few days. This was followed by an offer to join the Queen's Household as Assistant Privy Purse, and Assistant Private Secretary. I need hardly say that the latter offer was accepted.

The post of Equerry to Prince Leopold was later on conferred on Capt. S. Waller, R.E.

In regard to the above appointment it should be stated that, when General Grey died in 1870 he was succeeded as Private Secretary by Sir Henry Ponsonby; and when Sir Thomas Biddulph died in 1878, the whole of the responsibility of the two offices devolved on Sir

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Henry Ponsonby. For this latter arrangement an assistant was necessary, and when the offer was made to Edwards it was intended that he and Pickard should be assistants to Sir Henry Ponsonby, taking the work alternately. At first the year was divided in half, to enable Pickard, who was in delicate health, to be abroad in the winter. But Colonel Pickard died in 1880, and was succeeded by Major Arthur Bigge,* after which the "waits" reverted to what was the usual custom, each of the assistants in turn being on duty for three months. This arrangement continued until Sir Henry Ponsonby's death in 1895, when Fleetwood Edwards was made Privy Purse, and Arthur Bigge Private Secretary.

All public men must live a second life. There is the official side which absorbs more or less of their energy, according to the amount of interest they take in it, or the greatness of their sense of duty in regard to it; and there is the home side where the balance of their energy is spent, but where men, as a rule, like to rest and renew their strength. In the life at Court that Edwards commenced to live in October, 1878, there were periods on duty, and periods off duty. But the former meant more than ordinary work at an office. It meant actually living in the Palace where the Queen was residing, and being at the disposal of Her Majesty at any hour. So that even when he married in May, 1880†, it was found that he and his wife could not take a separate house. Edwards had to be at the Palace during his tour of duty, at meal times, and also at night, as well as at the ordinary office hours. So the only time when a home life was possible was when he was off duty. Now and then the Queen lent them a house at Osborne or Balmoral, and when Sir Henry Ponsonby died, and Edwards was made Privy Purse, they were given the Norman Tower in Windsor Castle as an official residence. The home life was consequently somewhat tied, but the Queen was invariably kindness itself, and both Edwards and his wife were perfectly devoted to her.

I will return to the home life again later on. Meantime I will endeavour to show briefly what the official life was in its entirety, and then as far as I can what it was in detail.

As I have already indicated, it was owing to his previous service in the Royal Engineers, and especially to his conduct when attached to the British representatives at the International Congress of Berlin, that Capt. Fleetwood Edwards was in October, 1878, selected by Her Majesty Queen Victoria to assist Sir Henry Ponsonby in his work at Court. In March, 1880, he was also appointed Groom-in-Waiting to

* Now Lieut-Colonel the Rt. Hon. Sir Arthur Bigge, G.C.V.O., etc., etc., Private Secretary to the King.

† Capt. Fleetwood I. Edwards married in May, 1880, Mary, daughter of Major John Routledge Majendie, 92nd Highlanders, her mother being a daughter of George Dering, Esq., of Barham Court, near Canterbury.

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the Queen. On the 30th June, 1883, he became a Major ; and on the 22nd October, 1890, a Lieut-Colonel of Royal Engineers. In October, 1888, he was made an Extra Equerry, and when Sir Henry Ponsonby died in May, 1895, he was made by the Queen, Keeper of the Privy Purse and Head of her Personal Household. The same year he was appointed by Her Majesty a Privy Councillor. In the *Times'* account of his life it is stated that "from the date of his appointment to the death of the Queen, Sir Fleetwood Edwards was perhaps the most trusted and intimate adviser of the Queen. Though shy and retiring in his demeanour, Sir Fleetwood Edwards was a man of remarkable charm, combined with a degree of steadfastness and determination which was hardly apparent to the casual observer. The life and influence of such a man must necessarily remain a sealed book to the public; but it may be stated with assurance that of the many devoted servants of Queen Victoria no one better deserved Her Majesty's confidence. On the death of Queen Victoria in January, 1901, Sir Fleetwood Edwards was named one of the executors of Her Majesty's will, a duty of extreme delicacy and importance, which he was peculiarly well fitted to perform."

It is said that he was consulted by the late King Edward VII. regarding the details of the funeral of the great Queen whom he had served so long and so faithfully, and whose body he accompanied, as one of the pall bearers, throughout the solemn and impressive three days' ceremony. Anyhow that Monarch thoroughly appreciated his services to the late Queen and thanked him personally for them. He created him a Grand Cross of the Victorian Order, and appointed him Sergeant-at-Arms in the House of Lords, granting him a pension. He also continued him as an Extra Equerry.

At the same time the Prince of Wales, who had a strong personal regard for him, offered him the post of Comptroller in his Household, but he declined the honour feeling that it would involve so much new work that he was unable to take it.

On his accession King George V. appointed him Paymaster-to-the-Household, and made him an Extra Equerry. His Majesty has also granted a pension to Lady Edwards in recognition of her husband's "great and brilliant services to Queen Victoria."

From what the *Times* states above, it will be gathered that Fleetwood Edwards' *full* life can never be written. We can give a few dates indicating when he occupied one or another of his appointments as an officer of Royal Engineers, or as an official at Court, and when he received some well-earned promotion or decoration. But, no doubt advisedly, he left behind him very few letters, and no journal. What was his daily life, and how his character grew until he acquired the influence and charm to which all who knew him bear record, we cannot tell. But we know that his official life at the Court was absolutely bound up in that of the great and good Queen to whom

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he was devoted, and we feel sure that at the same time he regulated all his actions by the precepts of the Divine Teacher in whom he thoroughly believed.

It may be interesting to friends who read this Memoir to know what was the routine of his official work, and what were some of the subjects that must have come before him during the 23 years, from 1878 to 1901, that he was employed at the Court. Soon after being appointed to the Royal Household it became Edwards' duty (as I have already stated) to assist Sir Henry Ponsonby in the combined work of Keeper of the Privy Purse and Private Secretary. This entailed six months' duty in the year, not consecutive, but usually from six to eight weeks at a time, the other half being taken by his colleague.

During the tour of office he lived entirely under the same roof as the Queen. All State papers passed through his hands. All telegrams were cyphered by him, not only on State, but also on family affairs. Consequently his work was of the most confidential and personal character with regard to the Sovereign. His hours of work were not accurately defined. Whenever the Queen was in the house, the assistant was supposed to be available. At Windsor, for instance, chapel was at 9, breakfast 9.30, luncheon 2, dinner 9 or 9.15. An hour's outing was allowed in the morning and two to two and a-half in the afternoon. All the household had their meals together except those who were "commanded" to dine with Her Majesty.

No doubt the work of the office was very close, and the Secretariat were usually kept at their desks until the Queen went for her daily drive late in the afternoon. The range too of the work was very great, involving as it did *précis* of Parliamentary, and ambassador's reports, and the sifting of the mass of letters which arrive daily for the Queen from all sorts of people. Then there was all the foreign correspondence, the distribution of the Queen's charities, etc., etc. The cypher telegrams took up a great deal of time, especially on the occurrence of any political crisis, when precedents had to be looked up. It has been said that during one crisis no fewer than 2,000 telegrams passed through the Palace office in a week. A friend writing of Edwards when he was assistant to Sir Henry Ponsonby says: "He was so conscientious in his performance of duty that I used to think in his early days at Court he suffered a good deal from the strain. Although doubtless it became easier as time went on, he was, after the Queen's death, glad to be relieved from further secretarial duties." Without the off duty periods it is quite possible that he might not have been able to carry on. But these, and the great kindness of the Queen in giving him occasional happy days of recreation among the moors and streams at Balmoral, or in the coverts at Windsor, enabled him to pull through. When, after the death of Sir Henry Ponsonby, Fleetwood Edwards was appointed Keeper of the Privy Purse and

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Head of the Personal Household of the Queen, he was brought into closer relations than ever with the Sovereign. His duties consisted in administering the funds of the Privy Purse, amounting to £60,000 a year, together with the income of the Duchy of Lancaster of which he was the Receiver-General. He had also charge of all the private properties of Osborne and Balmoral, the farm at Windsor, and the Queen's charities, besides the recommendation of candidates for Apartments at Hampton Court, for Brethren of the Charterhouse, and of Christ's Hospital, and for Pages of Honour, etc.

The people of interest that Edwards must have met and talked to while he was at Court were no doubt numerous. Governors and ambassadors proceeding to or from the places where they represented their Sovereign, admirals and generals taking up or relinquishing their commands, Ministers of State during their time of office, men and women of rank or distinction whom the Queen wished to honour by a "command" to stay for a night or more at the Palace. All or most of these he must have seen, many he must have known well, and made friends of. Then, connected with and made interesting by this personal acquaintance, there was all the correspondence, the reports, the despatches, the foreign confidential letters, the discussions in Parliament and elsewhere, and besides all these there were the written communications incident to appointments that had to be made by the Sovereign.

We have already stated how Edwards became acquainted with Lord Beaconsfield at the time of the Berlin Treaty. He no doubt continued his intercourse with that able Statesman and other members of the Party until the Conservatives were thrown out of power in 1880, and Mr. Gladstone became Premier with a large Liberal majority behind him. The times then were difficult. Irish questions were very much to the fore, and unexpected wars broke out in Afghanistan, in Zululand, in Natal against the Boers, and in Egypt. Edwards, I know, was particularly interested in the Zulu War, where the gallant young Prince Imperial of France, whom he knew well, went out as a volunteer, to serve with our army, and met his fate in a reconnaissance. He was also much interested in the Egyptian War of 1882, where the Queen's soldier son, the Duke of Connaught, commanded with distinction the Guards' Brigade. He was much concerned too at the delay that took place in relieving Gordon at Khartoum, which resulted in the death of that heroic leader before the British troops, under Lord Wolseley, could come to his assistance.

It need hardly be said that the debates on the Reform Acts which were eventually passed in 1884 and 1885 brought considerable additional work to the Court Secretariat. Still more excitement was caused in England, and consequently at Court, by the Home Rule Bill of Mr. Gladstone which caused several of his best known supporters such as Lord Hartington, Mr. Chamberlain, and Mr.

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Bright to leave the Government, and ally themselves with the Conservatives under Lord Salisbury.

The celebration by Queen Victoria of her Jubilee reign in 1887, and again 10 years later of her Diamond Jubilee, and the fact that these events brought into closer touch than ever the Queen and her people, could not fail to add very materially to the volume and importance of work that must have fallen upon Edwards at the time. All through the later years of the Queen's life but especially during the war between Great Britain and the Boers of South Africa, the spirit of affection for the Old Country and of loyalty to their Sovereign was growing in all those great States over the sea—India, Canada, Australia and New Zealand, and many other smaller ones—that make up the British Empire. This affection would show itself in more friendly relations, more frequent intercourse between the Court and the people, and would consequently result in a larger number of letters and telegrams, and additional anxiety to all those whose business it was to control and regulate the Secretariat that exists in the Palace of the Sovereign.

In concluding the record of Edwards' official life, which may be said to have ended with the death of Queen Victoria, I cannot do better, I think, than quote the opinion formed concerning him by Sir Arthur Bigge, the colleague who had worked in conjunction with him through nearly the whole of his time at Court, and who knew probably more about him than any living man. He writes that in the Household Edwards was a universal favourite, and was at the same time greatly respected. "His was a character of the strongest moral fibre: a man of deep religious convictions but so little did he obtrude them on others that many who did not know him intimately might have been quite unaware of his almost unique nature. He was always full of fun, absolutely devoid of priggishness, ready to join in every form of sport, but with all this he never deviated one inch from the path which he believed to be right. Such a man could have no enemies." Depend upon it his example must have helped onwards and upwards many of those with whom he was associated.

Not long after Edwards took up the work under Sir Henry Ponsonby in Queen Victoria's Household, Her Majesty gave him for his life one of the small houses in St. James's Palace. This was afterwards exchanged for a larger one, the back of which looks into the court where the daily guard is mounted. This house was a private not an official residence, and while the Queen was alive, Edwards and his wife lived there very little. When he was on duty they occupied the official residence in Windsor Castle, and when he was off duty they usually went for a trip abroad, or to stay with friends in the United Kingdom. On one of these occasions, having been granted leave for three months, they went for a tour to India.

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But, after the Queen's death, the house at St. James's became their home. Here they collected their pictures and books, etc., and here they lived when Edwards was carrying on his duty as Sergeant-at-Arms in the House of Lords.

From what has already been said we may feel sure that this duty was performed with as much regularity of attendance, and as much zeal, as any of the former work in which he had been engaged. But he was only required to be there while Parliament was sitting. The rest of his time he could regulate as he thought fit. I believe he liked the employment at the House of Lords because it brought him in touch with many friends whom he had made while he was at Court. It also gave him an opportunity of watching, from behind the scenes, how the machinery of Parliamentary life is worked. But it did not occupy his time as fully as had been the case in previous years, even including the extra employments of one kind and another that had devolved upon him. So he held himself available to take up charitable work when it came in his way. Moreover he never failed in helping to the best of his power those who came to him for advice and assistance. Writing of him at the later period of his time in the Royal Household one of his friends,* whom I have already quoted, says "Edwards always retained the same charming manner which he had in his younger days, and in his late times at Court was the trusted adviser not only of the Queen, but of many members of the Royal Family."

An extract from a letter written to him by his old chief, Sir Lintorn Simmons, some 12 years after the one I have already quoted, will not be out of place here, as testifying to the appreciation in which he was held by the Corps of Royal Engineers. "I was agreeably surprised on looking at the Gazette to see that you are promoted Lieutenant-Colonel, and most heartily and sincerely do I congratulate you and Lady Edwards thereon, for, although of late years, you have not performed many purely Corps duties, we all recognize in you one of our best and most distinguished officers, who is bringing fresh honours to the dear old Corps by the respect he has gained for himself, both from his Royal Mistress, and from all who come in contact with him."

In the year 1907 Edwards bought the Manor House, Lindfield, Sussex, as a place of retreat, during part of the year, from London. Here he was taken ill at the end of July, 1910, and here he died on the 14th August, the funeral taking place in the beautiful church and cemetery of Cuckfield, near Hayward's Heath.

Among the works of love that Fleetwood Edwards undertook during the last few years of his life, I will mention two, one being connected with the Corps of Royal Engineers to which he belonged.

* Colonel S. Waller, C.V.O., R.E.

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and the other with the Public School where he commenced his training.

When General Charles Gordon, R.E., was killed at Khartoum, among the black people whom he would not desert in their extremity, the people of England were eager to establish some national monument to his memory. This took the form of a training school for boys. The school, called the Gordon Boys' Home, was built on Government ground near Bagshot, and the management was vested in an executive committee, with an office at 6, York Street, St. James's. The late Chairman of Committee was Field Marshal Sir Lintorn Simmons, a friend of Gordon's. The present one is General Sir George Higginson, one of the earliest and most energetic promoters of the scheme. Edwards was a member of the Executive Committee.

In the *Gordon Boys' Gazette* of October, 1910, there is the following notice :—

FLEETWOOD ISHAM EDWARDS.

It is with the greatest regret we have to record the death of one who has been on our Executive Committee for 10 years, and a member of the Home for a still longer period.

While he took as keen an interest in the well-being of the Home as any of the Committee, his never-failing courtesy and kindliness were specially remarkable, and no one who was privileged to be connected with him in this or any other public matter will ever forget his charm of manner, and his delightful—almost boyish—geniality of temperament. Those who were still further privileged to know him in his home life will have no difficuly in understanding the estimation in which he was held by our great Queen Victoria, whose devoted servant he proved himself by so many years of faithful service. A more perfect "courtier" in the highest and noblest sense of the word it is impossible to imagine.

The Harrow Mission takes charge of and endeavours to work, in a systematic and thorough manner, the parish of Holy Trinity, Latimer Road, W.

Edwards was honorary treasurer of the Mission Accounts.

In the *Harrow Mission Magazine* of September, 1910, the Vicar* writes :—

"The death of Sir Fleetwood Edwards is a terrible blow to us, and I have tried in the following notice to explain how much he has done for us. His was a wonderfully unselfish life, lived one felt sure, always in the Presence, and always giving happiness to his friends, a man of infinite courtesy and kindliness."

* The Rev. Edgar Stogdon, M.A.

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SIR FLEETWOOD EDWARDS.

Very few people probably in the parish know how much help Sir Fleetwood Edwards gave us: he never liked it to be known that he was doing anything to help, and yet as treasurer of the Mission accounts he did a very great deal of work for us, and however busy he was, for he did numberless unrecorded acts of kindness, he was always ready to give up time to us. The keeping of accounts is proverbially dull, yet it was always pleasant to go and talk over business matters with him, because of his cheerfulness and humour. He was intensely keen about the Mission work and by his death we lose an invaluable helper, and a real friend.

Readers of the short Memoir that I have put together cannot fail to notice how the character that Edwards showed as a boy, trained as it was in a great public school and in a great military college, and tested during a diversified Army career, peculiarly fitted him for the employment that fell to his lot at the British Court. Whatever else he did, before and after, those 23 years that he spent in the service of Queen Victoria were without doubt the real work of his life.

How he did that work cannot be better told than by a quotation from the speech made by the Archbishop of Canterbury when, at a dinner given to Lord Hardinge, the newly appointed Viceroy of India, in November, 1910, His Grace had to propose the toast of Harrow School. He said "I cannot refrain to-night from alluding to two intimate personal friends of my own who within the last few months have passed away. One* of them was my exact contemporary at Harrow—and the other, in later years a still closer personal friend of my own, a man who, with singular reticence of dignity in his life, enabled few people perhaps to understand all that he was, and all that he was doing—Sir Fleetwood Edwards. I doubt whether many Englishmen realize what, during the later years of Queen Victoria's life, were the responsibilities devolving upon Sir Fleetwood Edwards, and how they were carried out. The quiet dignity of the man who held that position, and said nothing about it; the intimate personal counsellor and friend of Queen Victoria, the Private Secretary and Keeper of the Privy Purse, left as her executor when she died, the most marked token that could have been given of personal confidence, when, with a quietness and self-suppression which were beyond all praise, he filled the duties of one of the most difficult situations which any man could be called to fill. Few people outside his own immediate circle, or the immediate circle of those who were bound to know, realized either the greatness of the work that was being done, or the eminence, or the capacities of the man who was doing it."

A facsimile of two letters written to Edwards by the Queen herself, a list of the special appointments that he held, and a list of the honours that he received, are given in the Appendices.

* Sir Lewis Tupper.

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APPENDIX I.

List of Appointments, Etc., Held by Sir Fleetwood Edwards.

Aide-de-Camp and Private Secretary to the Governor of Bermuda. 1867–69.
Assistant Inspector of Works, Royal Arsenal. 1870–75.
Aide-de-Camp to the Inspector-General of Fortifications. 1875–78.
Attached to the Special Embassy at the Congress of Berlin. 1878.
Assistant Keeper of the Privy Purse, and Assistant Private Secretary to H.M. Queen Victoria. 1878–95.
Groom-in-Waiting to H.M. Queen Victoria. 1880–95.
Extra Equerry to H.M. Queen Victoria. 1888—1901.
Keeper of Privy Purse to H.M. Queen Victoria. 1895—1901.
Sergeant-at-Arms in House of Lords and Extra Equerry to H.M. King Edward VII. 1901–10.
Paymaster to Royal Household, and Extra Equerry to H.M. King George V. 1910.
Trustee of Queen Victoria's Jubilee Institute for Nurses.
Member of Council of Duchy of Lancaster.
Governor of Wellington College.
Royal Commissioner for Exhibition of 1851.
Member of the Council of the Royal Albert Hall.
Member of the Council of Queen Alexandra's House.

APPENDIX II.

List of Decorations and Honours Awarded to Fleetwood Edwards.

Companion of the Bath. 1882.
Knight Commander of the Bath. 1887.
Appointed a Privy Councillor. 1895.
Grand Cross of the Victorian Order. 1901.
Imperial Service Order. 1903.

And the following foreign orders:—
2nd Class of the Prussian Order of the Red Eagle, with Star.
The Coburg Order.

APPENDIX III.

Facsimile of Two Letters Written to Fleetwood Edwards by Her Most Gracious Majesty Queen Victoria.

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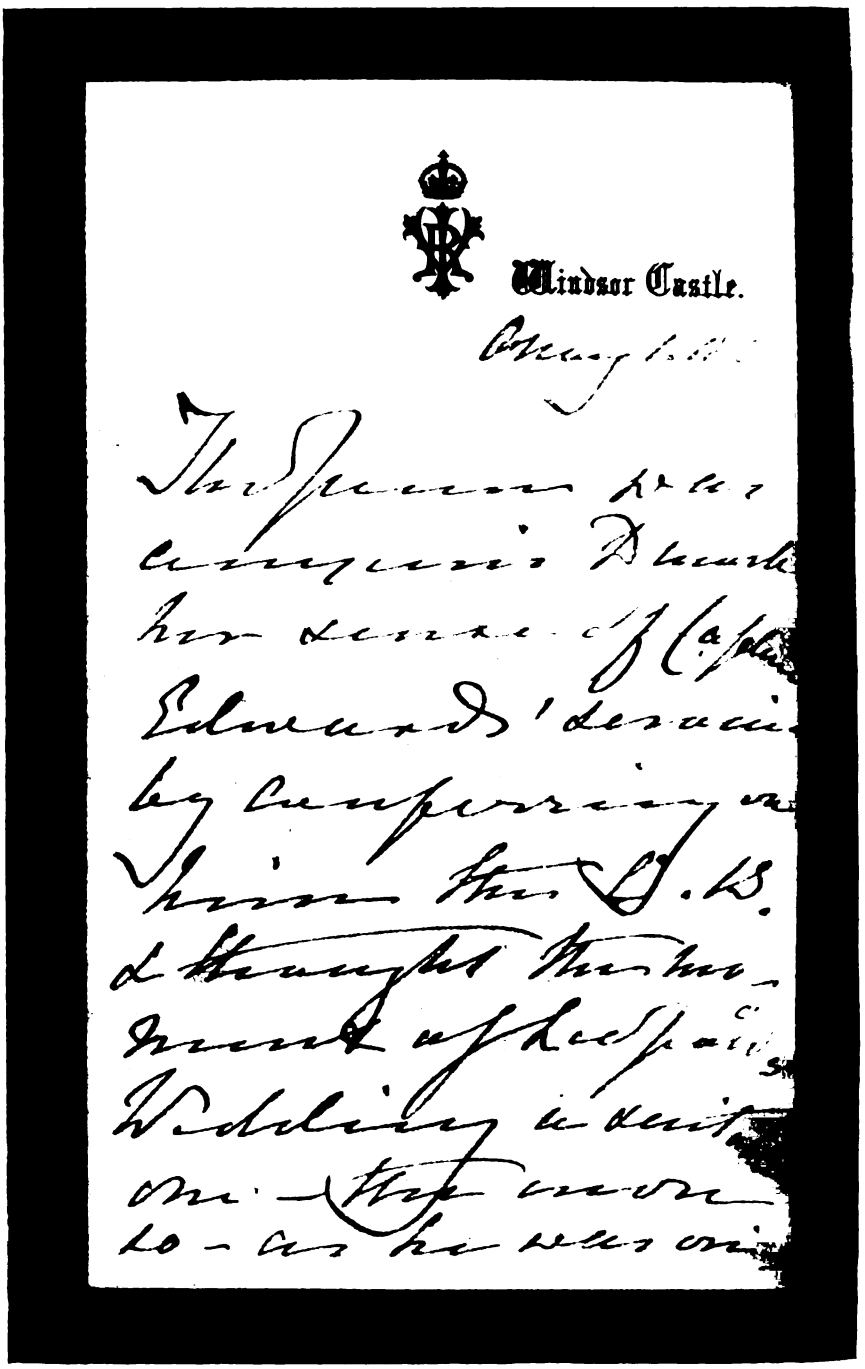
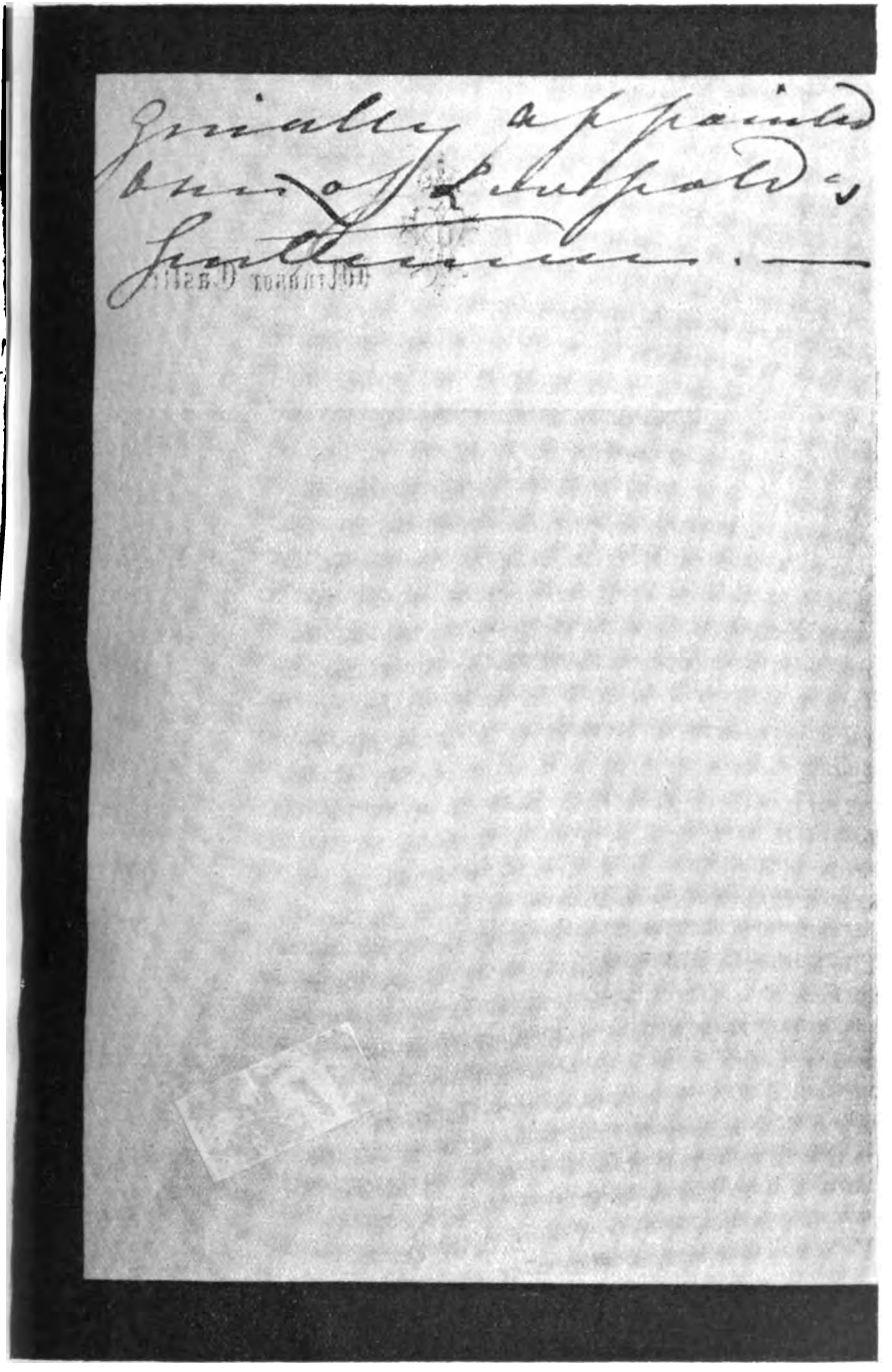

Windsor Castle.



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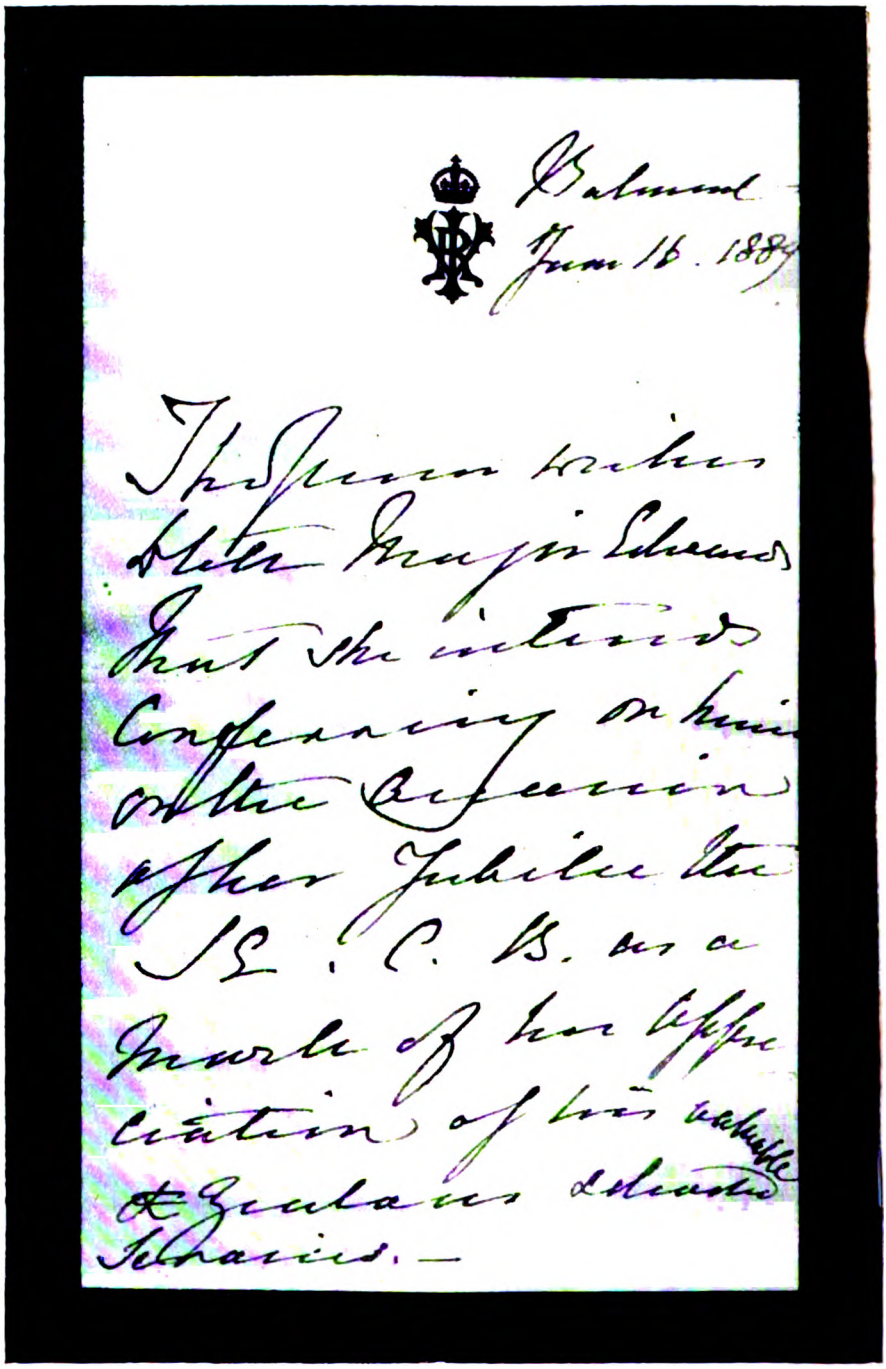

TRANSCRIPT.

MOBILE DETACHMENTS.

By Major A. Buddecke.

(Transcript from the Supplement to the *Militär-Wochenblatt*).

The further an army becomes removed from its own experience of war, so much the more must it draw on military history for guidance in its work in peace. This is especially indicated at all exercises which serve for training in the leading of troops. Mere imagination is not able to replace actuality in the framing of the schemes, and can but give rise to scenes which bear only the garb of war while having little in common with its essence. There is also the danger of falling into "cut-and-dried" methods, leading to one-sidedness. The scheme will only approximate to, and therefore form, a true preparation for the real thing when they are drawn from the fresh source of military precedents.

It is a striking phenomenon, that the schemes for great manœuvres favour situations in which a mixed force is situated independently or only in loose connection with the main body, and therefore appears as a mobile detachment. This kind of scheme finds its explanation in the fact that the situation of a detached force is able to be clearer defined than that of one in close co-operation with the main force, and sets the leader of it a completely independent decision to make. Great as are the advantages offered by such a scheme, it is yet only justified so long as it is based on reality, and does not do violence to facts through either setting up a force as detached, which as a fact is not detached, or by assuming a detachment, which is not justified by the military situation.

It should therefore be of interest and value to investigate the latest military history, and to find in what cases mobile detachments have been employed, what their experience was, and what signification they will have for the war of the future.

Independent forces are to be found in all stages of a war. Even at the commencement of a campaign their application may be necessitated by the political situation—if several opponents and menace from several directions have to be reckoned with. Desirable as it was in 1866 for Prussia to concentrate all her forces in the main struggle with Austria, yet the attitude of Hanover, Hesse, and the South German States, rendered mobile detachments imperative. But when the situation was materially improved through the disintegration of the Hanoverian Army, the decision of the Prussian Headquarters to unite the detached divisions of Beyer, Goben and Manteuffel to the Army of the Main, was of decisive importance. The use of these concentrated forces led to the overthrow of the South German armies, which, though twice as strong, were not concentrated.

The situation was similar at the commencement of the campaign in 1877–78. Here too on the Turkish side the political situation, the preceding battles with Servia, and the internal unrest, led to a dispersion of force, which compelled the use of divided armies against the Russians. Although the Turks obtained herewith the advantages of exterior lines and could

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operate against the flank of the enemy who had pressed across the Danube, they were only able to check the Russian offensive for a space, since they could make no concentrated use of their forces. Even Osman Pasha's bold flank stroke was very soon to be paralyzed by defensive action, to end finally in a severe reverse at the hands of the Russian forces, which steadily increased in numbers and tended to surround him. This example shows at the same time, that operations of separate portions of a force against the the flanks of an army that is concentrated, have little value if they do not go hand in hand with powerfully conducted operations against the front.

Geographical conditions, also, the one portion of the frontier projecting into the enemy's country, may result in allotting an independent *rôle* to the forces mobilized in that part. Thus the Austrian Headquarters at the beginning of the 1866 campaign, was able to derive advantage from the isolated situation of the 1st Austrian Corps and the Saxons. In the event of the Austrian Commander-in-Chief deciding to fall on the Prussian Army as it emerged from the mountains, with his main body, it would have fallen to the task of the 1st Austrian Corps and the Saxons to oppose the Prussian 1st Army and Army of the Elbe at the entrenchments of the Iser, until the Crown Prince's army had been disposed of; in the event of the Commander-in-Chief desiring only to hold the 2nd Prussian Army with a detached force, in order to throw himself with the main body on the advancing 2nd and Elbe Armies, the 2nd Austrian Corps with the Saxons had to hold the enemy till the main body of the army arrived. The vague ideas of the Austrian Commander-in-Chief and his indefinite orders for the conduct of the detached Corps had, however, the result that the latter, after showing a false front at the Iser, renounced this strong position and the road to Gitschin to the enemy, and by so doing exposed themselves to no inconsiderable tribulations. From this situation we learn how much with detachments of this sort depends on the orders, and how necessary it is not to leave the leader in doubt about one's own intentions.

The position of detached forces takes a particularly difficult shape when the Headquarters, as in the Russo-Japanese War, is forced to locate the place of concentration of the army very far to the rear. Thus, the pushing forward of a solitary portion of the army is only justified if there is an absolutely definite object, as the defence of a strong point of support, an important line of communication, or to prevent a landing. Tasks of a general nature, such as obtaining touch with the enemy, observation and the harassing of his advance, must remain in the domain of cavalry. According to this, on the Russian side, the despatch of strong detachments to Liaotang and to the Ussuri territory for the defence of Port Arthur and Vladivostock as necessary points of support for the fleet, was absolutely imperative, but the despatch of the Eastern Detachment under General Sasulitz to the Yalu was a strategical error. Its infeasibility is evident in the very instructions, which directed General Sasulitz to hinder the Japanese advance to the Yalu and later in the Schanboschan Mountains, but to refuse a pitched battle. It condemns the leader to some extent to the unattractive *rôle* of procuring his own defeat, even though he may see the possibility of victory. But even when the leader, suppressing all personal ambition, strives earnestly to act according to his chief's orders, it will in every case be difficult for him to form a sound

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judgment of when a fight may be undertaken and when it must be broken off. The boundary line between delaying and decisive action is very hard to draw and is easily overstepped even against the wish of the leader. For the heavy reverse at the Yalu therefore General Sasulitz is less to blame than the Russian Headquarters, which exposed their corps, in a position 200 kilometres in front of their main army, to the attack of superior Japanese forces. This kind of application of advanced corps can be designated "strategical advanced position," which is as little justified as the discredited "tactical advanced position."

Under otherwise normal conditions, operations of separate detachments can be introduced when the barrier of the frontier defence is to be pierced in order to obtain an insight into the enemy's dispositions, to hinder his mobilization and advance, or to secure a local advantage. Such operations, which are often worked out in war games, contain in themselves great dangers, especially if one has not got a start in preparedness so as to be able to establish or utilize advantages that are won. But they can be every bit as fateful, if they are only to cause embarrassment, as for instance to satisfy public opinion. In this connection the opening move of the French in 1870 affords a warning example. Froissard was able to do little against Pestel's detachment, but ran the danger at Spicheren of being destroyed by the advancing corps of the 1st and 2nd German Armies. So too the pushing forward of Abel Douay's Division at Weissenburg for the purpose of observation proved faulty.

Generally speaking the use of independent detachments in advance of the army at this stage of a war is not justified. The work of reconnaissance and observation is best left to the cavalry divisions, and the defence of the frontier to fairly weak detachments of all arms. Thus the detachments of von Pestel and von Steubert in 1870 and Count Stolberg and von Knobelsdorf in 1866, did good service and not only held the enemy at a distance but also deceived him as to the movements of their own army.

At the commencement of operations, detachments are best confined only to those found most necessary, for they always weaken the main body and may give the enemy a chance of a partial success.

In this connection the Russian conduct of the operations in 1904 affords a warning example The threat against Port Arthur induced the Russian Commander-in-Chief to forsake his original plan of assembling the army first of all at a distance from the enemy in order to subsequently crush him with superior numbers; he therefore started off for Port Arthur with the forces he then had available. For this march Stackelberg's Corps, which had been sent ahead, should to some extent have served as advanced guard. The task, which was given this corps, must consist in an offensive movement energetically carried out, the success of which was to be reaped by the army following behind. Only in this way could one hope to obtain a success over the Japanese forces in the field, and simultaneously to delay the investment of the fortress by acting in combination with the troops at Port Arthur. Instead of this General Stackelberg received instructions which gave his undertaking the character of a demonstration. "The corps under your Excellency's command is commissioned to advance in the direction of Port Arthur and draw to itself as many as possible of the enemy's forces and in this way to weaken

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their army operating in the Kwantung Peninsula. Therefore your advance against the troops pushed forward northwards for purposes of security must be quick and energetically carried through, so that these latter may be defeated as early as possible, it being understood that they prove to be weak. When you meet superior forces of the enemy the fight must not be fought to a finish, and the whole of the reserves must not be thrown into the fight so long as the circumstances are not completely clear." It is not to be wondered at that General Stackelberg with such an undefined task did not dare to act energetically when he encountered Oku's army of approximately equal strength to his own, and the opportunity was let slip of a victory which could turn the general situation to the favour of the Russians. So this "adventure," as Stackelberg's Chief of the Staff strikingly terms it, shares the fate of similar undertakings : the detached corps is beaten and thrown back on the main army with many losses. By this the Russian Commander-in-Chief was impelled not only to relinquish his active intentions, but also to withdraw the army again into its defensive position at Liaoyang. This first success however encouraged the opponent to assume the offensive which bestowed on him a lasting superiority over the Russians. The one and only advantage, which the move on Port Arthur brought, was a short delay to the investment of the fortress. The example also shows what dangers befall the strategical advanced guard.

Quite different is the case when at the commencement of operations the military situation of the opponent exposes weak points, of which use can be made, and when there is the possibility of seizing some point of importance for the course of the campaign, such as a bridgehead or a pass. Then it may be of great importance to push forward a separate portion of the army. Such a task was accomplished at the beginning of the Russo-Turkish War of 1877–78 by General Gurko, when he was sent with a mixed force of 12,000 to the Balkans after the Russian Army had crossed the Danube, in order to lay hands on the important Shipka Pass for the intended offensive movement of the army against Constantinople. The surprising raid of Gurko's, which, utilizing energetically the unprepared position on the Turkish side, not only took the mountain pass but also a considerable strip beyond it to the south, would have been able to bring the Russians in the shortest time to the final objective of their operations, if only the army had followed hard on the heels of this army advanced guard. But the available forces were not brought along so long as any threat on the flanks was possible, so that Gurko's success was partially discounted by the gradually increasing superiority of the Turks.

However this undertaking favourably influenced the issue of this war, and offers in its conduct a particularly typical example for a corps detached with a similar task.

A separation of forces, leading to a detachment of single corps, may also be justified if the advance against the enemy necessitates the passage of a considerable obstacle, such as a great river, a mountain chain, an arm of the sea, a swampy stretch of country, or one that is cut up by canals or a line of forts. The forcing of the crossing and the necessity of appearing on the far side of the obstacle with strong forces may necessitate advancing on a broad front in several columns. In this case

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one counts upon one column opening the way for the others, or upon its successfully deceiving the enemy as to the crossing place of the main body. Such an operation becomes the more audacious and difficult in proportion to the enemy's readiness for war. In this connection the Prussian invasion of Bohemia in 1866 remains an example for all time. The deployment of the 2nd Prussian Army from the mountains shows especially how very much the separate columns in such a case must depend upon themselves, so that they appear as if detached, and how much the success or failure of one column influences the fate of the others.

Such an advance can also mislead the opponent into making detachments if he has not fully mobilized his main forces, or if he is thinking of employing the latter in another direction.

The Austrian Commander-in-Chief found himself in such a situation. Intending to effect the concentration of his army at Josephstadt and then to advance against the army of Prince Frederic Charles, Benedek pushed forward the 6th and 10th Army Corps to Nachod and Trautenau, with instructions to attack with all their energy the columns of the 2nd Prussian Army as they emerged from the mountains. The course of the operations however shows that strong detachments are not indicated in such a situation. The victory of the 10th Austrian Corps over the 1st Prussians at Trautenau was amply compensated for by the defeat of the 6th Austrian Corps at Nachod and of the 8th Austrian Corps at Skalitz. In such a situation the defender will have more prospects of success if he keeps his forces concentrated, so as to defeat successively the portions of the enemy's army as they debouch. One must, to be sure, in this case act in such a way that the enemy can obtain no advantage from the possession of the exterior line. The passage of the Balkans by the Russians in 1877–78 teaches this. The united Turkish Army was waiting on the southern side of the mountain range for the Russian columns under Skobeleff and Mirski, which were advancing separated. It did not however succeed in defeating the Russian columns before they united. The result on the contrary was that the Turkish force, superior to each Russian column separately, was first of all tackled by one column, then surrounded by the others and finally forced to capitulate in the open country.

The passage of a river in view of the enemy, usually necessitates the use of detachments, if only for the object of making a demonstration. Thus the Russians at the passage of the Danube in 1877 acted in such a way that, in order to screen the main crossirg which was to be effected west of the Turkish Quadrilateral, they made the 14th Army Corps cross the river east of the Quadrilateral and occupy the Dobrudscha, whence General von Zimmermann was to delay the operations of the Turks against the Russian communications to the rear, and by assuming the offensive to attract the attention of the Turks to himself. This detachment, which was shortly reinforced by one division, fully achieved its object. It had however subsequently the great disadvantage, that these 1½ Army Corps remained here idle during the campaign and were lost for the main operations, so that the latter could not be carried through with the desired rapidity. Though, at this crossing of the Danube, the dispersion of the Turkish forces was to the advantage of the Russians, the more ready opponent in the Austro-Italian Campaign of 1866, managed to

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hinder the Italians at the forcing of the passage of the Po. Here too a force under General Cialdini was detached against the lower line of the Po, in order to deceive the enemy as to the offensive measures to be undertaken. The intention however failed and led to the great disadvantage that this force, five divisions strong, was paralyzed and did not take part in the main decisive action.

The commencement of the campaign of 1864 shows the successful forcing of a great frontal obstacle. Here too the advance of the Allies against the Danewerk and Schlei line was effected in several separate columns. The force under Prince Frederic Charles operated on this occasion quite independently, and by its crossing of the Schlei forced the Danes to evacuate the Danewerk position without a fight. In the later course of this campaign, also, the Allied Headquarters sought to utilize detachments in that it decided, on the advice of General von Moltke, to cross a force over to Alsen for the support of the attack on the Duppel fortifications, and for the preparation of a complete defeat of the main forces of the Danes

Separated objectives too may lead to a division of the forces, as taught by the proceedings on the Armenian theatre of war in 1877–78. The Russians here operated in four columns, each of about 25,000 men, against Batoum, Ardagan, Kars, and Bajaste. They were thus able to act decisively nowhere, whilst a united offensive undertaken against the Turkish Field Army would have promised a certain success, from which the attainment of their secondary objectives would naturally have resulted.

The marches to the main decisive battle are carried out in the closest concentration as a rule with the purpose of preparedness for action, while utilizing fully the network of roads. This procedure is particularly indicated if accurate information as to the enemy's situation is lacking. One then has at least the intention of concentrating superior force at one place. Napoleon owes his greatest successes (*e.g.* Jena) to obedience to this principle. When he acted contrary to it, as in the winter campaign of 1806–7 at Pultusk and Eylau, his attack lacked the power to annihilate. A departure from this rule can however be occasioned by the difficult nature of the country. Thus the corps of the 2nd German Army in 1870–71 during the advance on Orleans, and later on Le Mans, were kept apart through the peculiarity of the country and so resembled detachments, so that a series of local engagements took the place of a general decisive action. This situation offers therefore a quantity of examples for independent action by subordinate leaders.

During the advance of separated groups of an army from different directions it may be advisable to fit in a connecting link, in the manner that the Japanese Headquarters during the advance on Liaoyang introduced as an independent force the Takushan detachment, consisting of the 10th and half the Guard Divisions, for the purpose of connecting the 1st and 2nd Armies.

The protection of the flanks against neighbouring hostile forces or against fortified places, can also lead to the use of detachments which must act offensively or defensively according to the situation. But the smaller the forces that are used to carry out this subsidiary task, the better is it for the main operations. The conduct of the Japanese in 1904 offers a noteworthy example of this, since they only left one division opposite Port Arthur after the capture of the Nan Shan position and

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marched off with all the remainder for the main decisive action. They were justified in this boldness, as they could well hope in that strong position to be able to maintain the investment of Port Arthur from the land side until the troops told off for the siege had arrived. A similar task fell to the Baden Division in 1870, which in the advance of the 3rd Army against the Upper Moselle was left as a protection against Strasbourg and the French forces which had appeared in Upper Alsace.

The Italian Headquarters in 1866 fell into the error of making too strong a detachment, when 3½ divisions were left opposite the weakly held fortresses of Mantua and Peschiera during the advance across the Mincio for the decisive battle. The lack of these forces was sorely felt at Custozza.

In the phase of the main decisive action mobile detachments are but seldom found, since both sides act on the principle that one cannot be sufficiently strong for the main decisive action. Envelopment of the enemy, which is so much sought after and so often decisive, is almost always effected solely by outflanking in advancing on a broad front, or by pushing up portions that have been held back, as shown by the development of the battles at Worth and Sedan by the Germans. But the defender will seldom so lay himself out on the operating table, that he leaves the attacker time to make up his mind in advance where he has to apply the knife. One must count on a mobile adversary, and will not as a rule have such extensive information about him that an envelopment can be reckoned on with any certainty when arranging the advance.

Thus, the German Headquarters on the 18th August, 1870, were only able to make their arrangements for the envelopment, in accordance with the reports coming in during the course of the day about the position of the enemy's right wing, and the envelopment therefore could only be brought about by a further drawing up of the portions of the army that were in rear. In this case it may occur that one is completely deceived as to the situation of the enemy's wing, and that the troops allotted to the enveloping movement strike the enemy in front, like the IX. Corps at Amanvilliers and the 16th Infantry Division at the Hallue. In the latter case General von Manteuffel was thrown, by this error, from an intended offensive into the defensive, and was only enabled to overcome the strength of his opponent by a stubborn resistance.

In fact but few instances are to be found in modern military history, where, as at Bautzen, detached forces have given the decisive blow in the main battle by coming in on the enemy's flank. Even "marching to the thunder of the guns," so beloved by the Germans, to which we owe a portion of our successes, leads only in exceptional cases to a real envelopment. Thus at Spicheren the wide turning movement of the 14th Division through Volklingen and Rossel on Forbach, did not have the desired result, as it came too late and was not carried through sufficiently energetically. Leaders of such detachments, especially if they are not kept sufficiently informed as to the state of the main fight, allow themselves only too easily to be intimidated and held up by the determined resistance of even weaker hostile forces. An exception to this is shown in the action of General von Lestocq at Eylau, who held off the advance of Ney by a detachment, and intervened with his corps in the main battle.

Only an extraordinary situation, such as led to the Battle of Vionville,

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offers one of the few historical examples where the battle arises from the successive intervention of detached forces. But here too it appears that the leaders of the detached corps, feeling their weakness, are inclined rather to seek close touch with the troops already engaged than to operate independently against the enemy's flanks.

In the above crisis the departure of a single portion of the army out of the frame of the whole is always dangerous, as evidenced by the defeat of Mortier's Corps before Austerlitz in 1805, and especially so is the pushing forward of part of the army for the purpose of a reconnaissance in force. Such action involved the Austrians in 1859 in a partial defeat at Montibello without their having cleared up the situation in the manner desired.

The writer then proceeds to deal with the use of detachments in the pursuit, in the further advance into the enemy's country after the first successful battles, and, in the case of the unsuccessful side, in retreat.

In conclusion he says: On the whole after this glance at recent military history it may be said that mobile detachments have found a place in all the stages of the conduct of war, but frequently, being incorrectly applied, have proved disadvantageous. Though there are therefore only exceptional cases, when the despatch of independent forces has proved advisable, yet in future in a European theatre of war there will be still less opportunity for their use.

The characteristic of coming events of war will be the massing of large numbers in a narrow space, which will be manifested not only in the stage of the decisive battle, but even in that of the preliminary movements, since the constricted area and considerations of simultaneous action compel this. The saying "Separate to march, unite to fight" could only maintain its full meaning so long as the portions of an army were smaller and more mobile and had sufficient room. But in the future the forward movement of a deployed army will present the spectacle of a single, almost unbroken wave, rolling on the opponent. The decision in the gigantic battle will ensue chiefly in a frontal struggle, and will consist of a number of local successes wherein the pushing of forces into and behind the battle front will play a great *rôle*, as has already been manifested in the decisive battles of the Russo-Japanese War at Liaoyang and Mukden. With the great distances prevailing it will be impossible to count, with certainty, upon the timely arrival of detached forces at the decisive place, even though in highly cultivated countries the development of the network of railways is able to some extent to compensate for the clumsiness of the movements of armies. So it follows that with the modern utilization and composition of the cavalry divisions, the latter in many cases may be able to replace mixed bodies of troops, and be in a position to keep hostile detachments at a distance from the decisive battlefield. But subsidiary successes, which in former times could bring about a complete change in the military situation, scarcely count any longer as compared to the decisive battles.

With the growth of army masses, therefore, the possibility and suitability of mobile detachments diminish. The subordinate leader will for the most part act in close co-operation and will seldom find opportunity for completely independent action.

E. G. WACE.

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REVIEWS.

EXPANDED STEEL FOR REINFORCED CONCRETE CONSTRUCTION.

The Expanded Metal Company, of York Mansion, York Street, Westminster, have produced a new pamphlet illustrating and describing the materials manufactured by them.

This pamphlet contains tables giving full details of the various forms of expanded steel both in the commonly known diamond mesh form and also, in their latest products, rib mesh expanded steel and expanded (p. 233 of pamphlet) steel bars. These tables give all the information necessary in ordering expanded steel in any form and the notes giving the standard sizes of sheets are most valuable.

Some brief notes are given on the advantages of expanded steel in its various forms as a reinforcement for concrete, combined with a short specification for cement and aggregates with clear directions as to laying.

This pamphlet also contains tables of foundations and slabs, giving the necessary thicknesses under various conditions of loading, illustrated clearly and showing how the results are obtained. The calculations throughout being based on the R.I.B.A. formulæ and a low value assigned to the resistance of concrete in compression, the thicknesses given are well on the safe side.

There are many excellent illustrations showing the uses to which expanded steel can be put in the shape of floors and roofs, domes, silos and coal hoppers, water tanks, bridges—*Fig.* 1 (p. 142)—reservoirs (circular and rectangular), pipes, aqueducts and sewers. Also expanded steel and concrete watertight canal beds (*Fig.* 2).

A use which may be of considerable interest to R.E. officers is the use of expanded metal in combination with concrete in coast defence works. There can be no doubt that properly placed reinforcement must materially assist concrete to withstand the disintegrating effects of waves, and a reinforcing material such as expanded steel is eminently suited to this purpose.

Expanded steel has also been used in the construction of many things not usually made in concrete—even combined with steel, as examples *Fig.* 3 (p. 225) shows a reinforced concrete barge constructed in Italy of concrete reinforced with round bars and expanded metal. *Fig.* 4 (p. 230) shows railings and a figure on p. 228 some details of sleepers, all constructed of concrete reinforced with expanded metal.

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REINFORCED CONCRETE BRIDGE AT ABERSYCHAN.

EDWARD WHITWELL ESQ., ABERSYCHAN, – Engineer. –

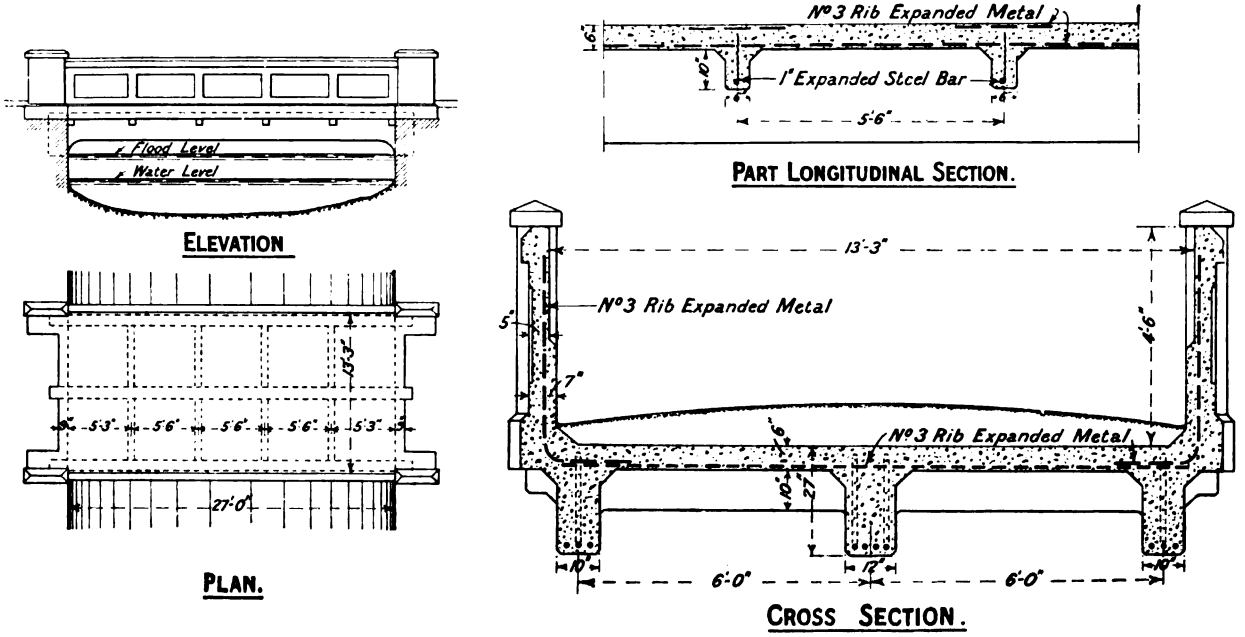

FIG. 1.

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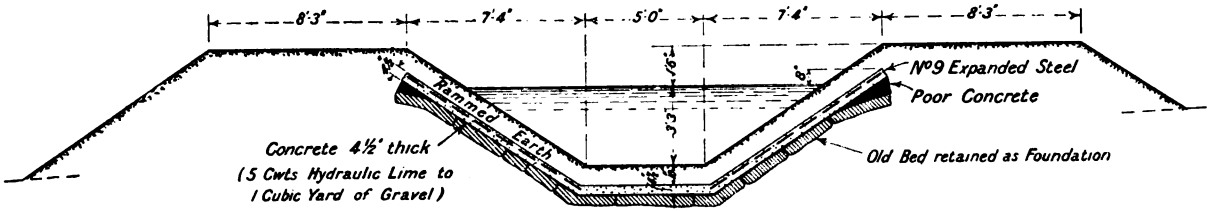
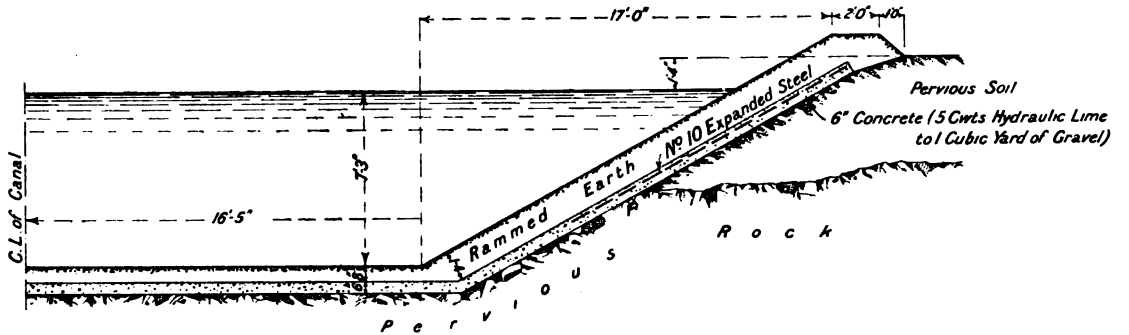
BURGOYNE CANAL,— EXPANDED STEEL & CONCRETE WATER-TIGHT BEDS.



CROSS SECTION OF SUPPLY CHANNEL AT CHAZILLY.



HALF CROSS SECTION OF CANAL

FIG. 2.

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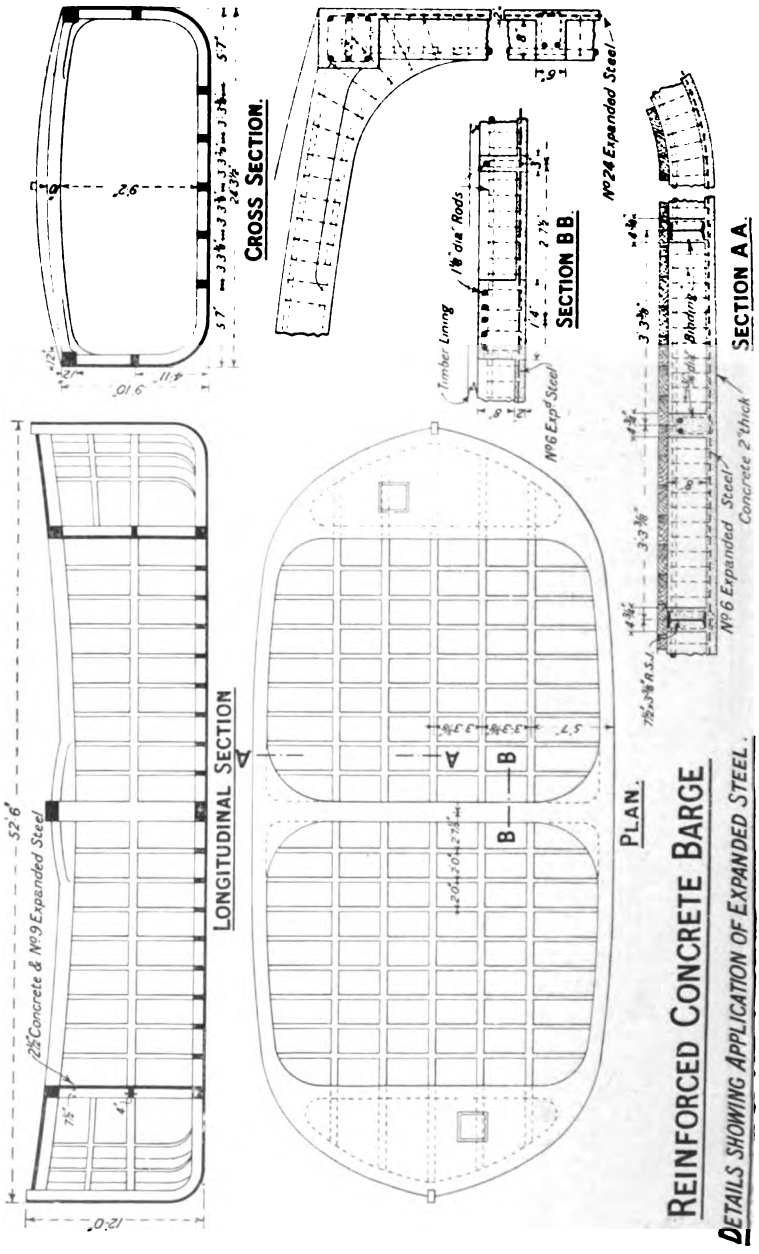

FIG. 3.

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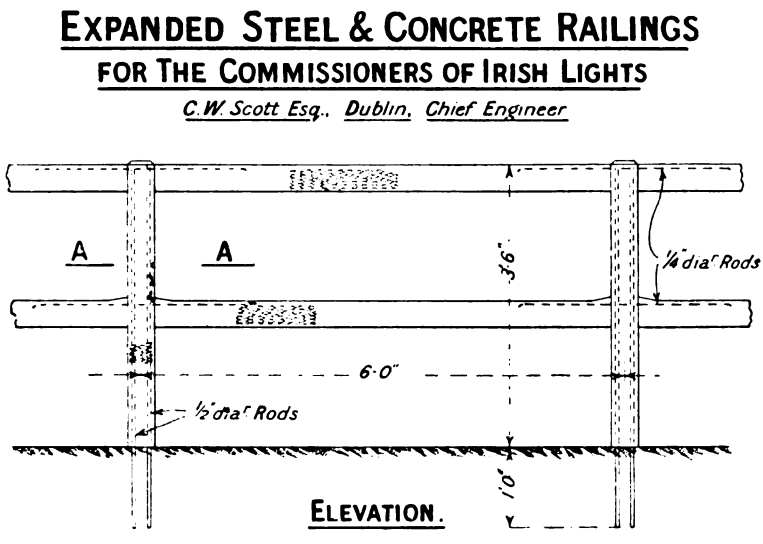

FIG. 4.

The information given in this pamphlet illustrates very clearly the many uses to which reinforced concrete can be applied, and shows to what a number of uses expanded steel can be utilized as a means of reinforcement, and the book itself is strongly recommended to the notice of all R.E. officers.

J.G.F.

DANCING ON SKATES.

By COLONEL H. V. KENT, R.E.—(R. Ward & Sons, Ward's Buildings, High Bridge, Newcastle-upon-Tyne. Price 1s.).

In this little book Colonel Kent has recorded in print two things for which officers who have served at Halifax will be grateful, first the various figures of the Lancers as danced on skates, and secondly the style of waltzing on ice in vogue in Canada. The booklet can easily be carried in the pocket and should be invaluable to parties of skaters who want to acquire the art of dancing the Lancers either on rollers or on the ice. A sub-title is "A Plea for the Circular Waltz." The English style of waltzing requires everyone on the rink to be practised waltzers, and does not admit of full advantage being taken of the power of wide sweeping movements with little exertion conferred by skates. The Canadian style is easier to learn and more enjoyable when learnt. Colonel Kent will be a public benefactor if he secures its introduction in rinks at home. The 20 diagrams illustrating the letterpress are on the right hand of each page facing the verbal descriptions of the figures, making the book very convenient to consult when learning the figures in the rink. All skaters who want to dance may well expend a shilling on it.

A.M.H.

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RECENT PUBLICATIONS OF MILITARY INTEREST.

JANUARY, 1911.

(*Published Quarterly*).

THE following extracts from the list compiled by the General Staff, War Office, are published in the *R.E. Journal* by permission of the Army Council.

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*PART II.**

SECTION I.

AERIAL NAVIGATION.

THE FLYING MACHINE (Plus lourd que l'air. La Machine Volante). By Capt. Jules Raibaud. 178 pp. Paris. A. Lahure. 3s. 2d.

This is a useful little book for anyone wishing to gain some elementary knowledge of the theory and principles of aeroplanes. The opening chapter gives a very brief account of the early experiments of Lilienthal, Ader, Wright and other pioneers. The author then proceeds to explain the principles of the aeroplane, and in some 30 pages discusses the reasons for the elevating and steering rudders, the "ailerons," and closed compartments of certain biplanes, and similar problems. This is the most valuable part of the book, and the text is illustrated by diagrams. In Chapter III. the various existing types of aeroplanes are explained. Another 40 pages are devoted to the actual theory of heavier-than-air machines, but only a mathematical expert can follow the author. The remainder of the book deals with the employment of aeroplanes and the probable lines on which they will be improved.

BOOKS OF REFERENCE.

THE JAPANESE ARMY IN 1910 (Die Japanische Armee im Jahre 1910). Austrian translation from original Russian work by Lieut.-Colonel J. Romanowski, by Colonel Pruszynski, Austrian Army. 97 pp., with 9 appendices and table of contents. 8vo. Vienna, Teschen. Leipzig, Karl Prochaska. 4s. 6d.

The translator has previously published several useful works concerning the Japanese Army, and the writer was joint-author of Schwarz and Romanowski's well-known work on the siege of Port Arthur. The different portions of the book deal with – I. Field troops (higher staffs, the various arms, technical troops, reserve formations); II. Armament and munitions of war; III. Training regulations; IV. Protection, marches, cantonments, defences.

Appendices deal with :—

(1). Number of divisions in army.
(2). Constitution of a division.
(3). Data concerning artillery.
(4) to (9). Uniforms and distinctive marks.

* The titles of all books are given in English; this does not indicate that the books have been translated. The original title in the language in which a work is written, if not in English, is given in brackets.

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Some of the data given concerning artillery differ from those supplied from official sources, *e.g.*, horse batteries are stated to consist of six instead of four guns. There are some errors in the book. The distinctive badge of Staff College graduates is said to be that of the General Staff. The divisional artillery is said to consist of three instead of six batteries. The organization of heavy artillery is erroneously described.

The distinctive flag of the second battalion of a regiment is given as that of the third battalion, that of the first as second, that of the third as first. Engineers wear crimson and not chocolate-coloured gorget patches. The unit of three (two) batteries is translated as "division," the usual Austrian term.

Despite the few slips referred to the book forms a valuable work of reference.

FORTIFICATION AND MILITARY ENGINEERING.

WORK ACCOMPLISHED BY THE ITALIAN MILITARY ENGINEERS IN THE LOCALITIES AFFECTED BY THE EARTHQUAKE OF DECEMBER, 1908 (L'Opera Prestata dalle Truppe del Genio nelle regioni colpite dal terremoto Dicembre, 1908). By Lieut.-Colonel Nicoletti-Timari. 2 vols., one of 78 pp., one of photographs and diagrams. 8vo. Rome, 1910. Voghera.

The Italian War Office despatched 34 companies of Engineers to the scene of the earthquake in December, 1908. These were eventually organized in four groups, with headquarters at Reggio, Palmi, Bagnara and Messina respectively.

This book gives a vivid idea of the variety and extent of the work that these companies were called upon to do. Not only had they to construct over 400 huts for the accommodation of the inhabitants, but to them also fell the duty of demolishing unsafe buildings, repairing the roads and railways, re-establishing the telegraph and telephone systems and constructing landing stages and jetties. The photographs and diagrams give a clear idea of the nature of the work done.

HISTORICAL.

THE DEFENDERS OF SEVASTOPOL. By General P. F. Rerberg. Vols. I., II., III. 418 pp. Profusely illustrated. Oblong 8vo. St. Petersburg, 1903, 1904, 1907. Golke & Vilborg.

In 1901, General Rerberg of the Imperial Russian Engineers, a veteran of the Crimean War, announced his intention of compiling a representative collection of portraits of officers and men of all ranks who took part in the defence of Sevastopol. The collection is now completed and is dedicated to the defenders of Sevastopol. The three albums contain altogether 1,332 portraits, accompanied in most cases by a short biography of the individual; a number of these portraits date from the period of the Crimean War.

The collection includes photographs of Sevastopol taken at the time of the Siege, and some interesting groups taken in 1905 of veteran survivors of the campaign.

General Rerberg has forwarded a presentation copy of his work to the Imperial General Staff.

THE SPANIARDS IN MOROCCO, 1909 (Les Espagnols au Maroc en 1909). By General de Torcy. 279 pp., with 1 map, 5 sketches. 8vo. Paris, 1910. Berger-Levrault. 4s. 2d.

General de Torcy acted as chief of the staff to the French expeditionary force in Madagascar, and much of his brilliant military career has been passed in Algeria: the distinguished record of the author thus lends great weight to his comments on the Spanish Campaign at Melilla in 1909.

The book is divided into three parts. In the first is traced the history of the Spanish North Africa possessions: the second part deals with the operations, which are clearly and instructively described. The third part is reserved for the comments of the author.

In the third part which constitutes a miniature handbook of warfare in North Africa, stress is laid on the value of the doctrines originally laid down by General Bugeaud and

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subsequently developed by his successors in Algeria. These doctrines had not been followed by the Spanish commanders, who consequently clung to the old methods of lines of small entrenched posts and did not realize the fatal effects of undue delay and hesitation in operations of this nature.

General de Torcy speaks in terms of admiration of the gallantry, discipline and power of endurance of the Spanish troops, but considers them to be rather lacking in dash and elasticity, while their system of military training leaves a good deal to be desired.

RECOLLECTIONS OF THE RUSSO-JAPANESE WAR. By Colonel E. I. Martinov. 8vo. 402 pp. Maps. Plotsk Government Press, 1910. 5s. 3d.

Colonel Martinov was appointed to the 143rd Zaraiski Regiment on the outbreak of the war, and commanded it throughout the operations of 1904. In this book he relates at length the part played by the Zaraiski Regiment in the great actions, and in the various minor operations of the campaign. The book throws a very interesting sidelight on the interior economy of a Russian unit in the field. The Zaraiski Regiment had, apparently, a considerable regimental fund. The foresight of the commanding officer added to the regimental transport by local purchase, furnished the men with garments of Chinese linen for the summer, and with fur-lined jackets for the winter, with extra boots, and with a cobbler's depôt in Mukden for their repair. When the divisional intendance reduced the meat ration, the Zaraiski Regiment made up the deficiency from their own store beasts; and when the divisional general showed a weakness for utilizing too often the mounted section of regimental scouts on detached duty, Colonel Martinov solved the difficulty by forming a duplicate scout section for his own use. The field kitchens were always on the spot when needed, and when the situation did not admit of their being set up to the front line, the men received their cooked rations in haversacks. Any lull in the fighting was taken advantage of to issue a meal, or to order the men to sleep, and finally when the regiment went into winter quarters on an entrenched position they built themselves baths and a laundry. Such details scattered throughout the book, in spite of its modest tone, reveal the fact that the Zaraiski Regiment was fortunate in its commanding officer, whom it lost when he was appointed chief staff officer to the IIIrd Siberian Army Corps.

The book is interesting, and is written in simple style and in very easy Russian. The student of this language will find it valuable for the introduction it gives to military life, and also for the many military terms which it contains. The print is very good and the sketch maps are clear.

HAVELOCK'S MARCH ON CAWNPORE, 1857; A CIVILIAN'S NOTES. By J. W. Sherer, C.S.I. 367 pp., with 1 portrait. 12mo. London, 1910. 1s.

An entertaining little book, in which interesting sidelights are thrown upon some of the events of the great rebellion.

RUSSIAN OFFICIAL HISTORY OF THE RUSSO-JAPANESE WAR. Vol. I. Part I. (Guerre Russo-Japonaise 1904—1905. Historique rédigé a l'état-major-général de l'armée russe). 666 pp., with 2 maps. 8vo. Paris. 1910. Chapelot. 12s. 10d.

The French edition is as nearly as possible a translation *in extenso* from the original Russian. The work is being carried out by 20 officers, principally officers of the staff, under the superintendence of the Headquarter Staff.

Vol. I., Part I., contains five chapters, *i.e.*, half of Vol. I. of the Russian original. The five chapters treat of:—

Chapter I.—Events prior to the outbreak of war.
Chapter II.—The theatre of operations.
Chapter III.—The Russian strategic deployment and plan of campaign.
Chapter IV.—Reinforcement of the Russian troops.
Chapter V.—The Japanese Army.

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The account of the events prior to the war seems on the whole fair. The reader is struck by the contrast between the future combatants—in Japan a Government urged by the people and the Press to war—in Russia the people indifferent and a Government hopeful of gaining its ends by diplomacy, though urged as early as October, 1903, by the man on the spot, the Viceroy in the Far East, to mobilize in Siberia. Admiral Alexyeev understood that no arrangement compatible with the dignity of Russia would satisfy Japan, and the Russian Military Attaché sent frequent warnings to St. Petersburg of the activity at the Japanese Ministry of War.

Yet when the rupture came Russia, whose Foreign Office had striven to the last for peace, was unprepared. Diplomacy, gambling on the possibility of peace had neglected to provide for the eventuality of war, and the army was left to fight without allies. Great Britain, Germany and China, whose attitude was of primary importance were either semi-hostile or held aloof and the rear in Europe, the right flank and even, to a certain extent, the rear in Manchuria gave cause for anxiety. On the other hand Japan had won, if not the active alliance, at all events the moral support and sympathy of Great Britain and America, the two Powers with the strongest fleets and the longest purses.

Pages 107 to 198 of Chapter II. are devoted to a minute description of the theatre of war.

The remainder of the chapter contains an interesting criticism of the gaps in the Russian intelligence concerning the army and resources of their future enemy and of the probable theatres of war. Military Attachés at Tokio complained of the difficulty of obtaining information in Japan. Compared to the people of western nations, the Japanese were extraordinarily secretive, secret agents were unobtainable, there was no military Press and the translation of the few documents that came to hand offered exceptional difficulty. Russia remained to the end without precise information regarding the strength of the Japanese first line troops, the organization of the reserves and the wonderful *moral* of the army. It is a common Russian fault to keep secret matters which should be communicated to a large number of officers. Hence though much information had been collected about Manchuria, its publication had been delayed and conditions in the Far East brought many surprises for the bulk of the troops called upon to serve there.

Chapter III. contains a summary of the various plans which were drawn up for a campaign against Japan from 1898 to 1903, in which years conditions in the Far East were constantly changing owing to the rapid growth of the naval and military power of Japan, the steady but slower increase of the Russian forces and the improvement of communications in Manchuria.

Pages 320—328 set forth the main lines of the scheme drawn up by the Viceroy's staff in the autumn of 1903 and some interesting remarks thereon by General Kuropatkin, then Minister of War. Admiral Alexyeev's appreciation of the situation was optimistic. He assumed that Russia would retain the command of the sea and that the Japanese Army would be unable to land N. or W. of Chinampo. Kuropatkin considered that the Japanese would probably try to capture Port Arthur and would then await the assumption of the offensive by the Russians on the line Gensan-Pingyang. He foresaw that the Russian forces would be in an inferiority in Manchuria for the first six months after the outbreak of war and that the Liao-tung Peninsula would be isolated from perhaps the second month. He advocated the reinforcement of the garrison of Port Arthur and the bold employment of the field army which should endeavour to tire out the Japanese by means of its overwhelming force of cavalry and by frequent resort to operations by night. On the other hand he emphasizes the necessity of avoiding encouragement to the Japanese by partial successes at the outset of the campaign.

Pages 328—331 give the origin of the initial distribution of the Russian fleet. The object of the main squadron, which was based on Port Arthur was to prevent a Japanese landing on the coast of the Liao-tung Peninsula, that of the Vladivostok detachment was to raid the enemy's rear and the weakly fortified ports of the Japanese coast and to act as commerce destroyers.

On the 15th February, Kuropatkin in a note to the Emperor (pp. 360—362) sketched the probable course of the war, laying particular stress on the necessity for caution pending the concentration of sufficient force and the need for light railways. On the following day he was selected by the Emperor as Commander-in-Chief in the field from a list of 10 officers which he had himself drawn up on the 9th February.

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Chapter IV. gives some idea of the difficulties under which the Russian administration laboured when it at length understood that war was inevitable. On page 462 and subsequent pages will be found a detailed statement of the strength and distribution of the Russian troops in the Far East at the outbreak of the war.

Chapter V. starts with a short account of the growth of the military power of Japan from the year 1871 and of the organization of the army in 1903.

Page 535 and the following pages, which contain a candid and searching analysis of the Russian intelligence of Japan prior to the war, will probably be found the most interesting in the volume.

Principally owing to the impossibility of obtaining precise information of the reserve formations, the Russian estimate of the available strength of the Japanese Army fell far short of reality. The official handbook considered 320,000 to be the highest number that could be mobilized and the most liberal estimate in the reports amounted to 634,000. In the war itself, the Japanese mobilized and employed 1,185,000 men.

The failure, however, to estimate adequately the numerical strength of the Japanese forces was of trifling importance, compared with the inability to appreciate their training, endurance, patriotism and *moral*. The attachés at Tokio previous to 1900 reported the astonishing progress of the army, but in that year Lieut.-Colonel Vannovski was appointed Russian representative.

The new attaché's first report contained the opinion that "decades, perhaps centuries" must elapse before the Japanese Army would be able to fight on equal terms with the feeblest of European Powers. A note on this report by the Minister of War (Kuropatkin) complimented the author on his common sense and on the absence in his report of evidence of the fascination exercised by the Japanese Army upon former military attachés. Whether Vannovski saw Kuropatkin's note or not is unknown, but his reports continued in the same strain and his preconceived opinions affected the judgment of the Russian observers who attended the Japanese manœuvres in 1901. Apart from animadversions on the poor quality of the horses and the miserable horsemanship of the mounted troops, their reports dwelt on the "feebleness of the tactical training," the absence of bayonet attacks, the distaste for operations by night, the disregard of cover, the want of proper measures of protection, the lavish expenditure of ammunition, the absence of all directing criticism at manœuvres, the want of discipline, the inability to withstand extreme cold, the ignorance of the military arts and the conceit of the officers. It was stated that the Japanese were a nation "without a future," and that their army was an "army of babies."

General Jilinski, Q.M.-General at Army Headquarters—a position corresponding to that of our Director of Military Operations—somewhat discounted these reports but still even he stated that "there can be no doubt that the Japanese Army cannot possibly be compared to the chief European armies and especially to the Russian."

In September, 1902, Vannovski was replaced by Lieut.-Colonel Samoïlov, who took a more favourable view. Kuropatkin's impressions of the army gathered during his visit to Japan in 1903 will be found on pp. 584—585. He commented on the absence of religious sentiment in the country as a weakening factor.

Pp. 594—603 contain nothing new, but set forth clearly and forcibly the disadvantages under which the Russians laboured at the outset of the war as compared with their opponents.

THE STORY OF THE FRANCO-PRUSSIAN WAR, 1870–71. Part II. Metz to Sedan. By Lieut.-Colonel H. M. E. Brunker. 70 pp., with map. 8vo. London, 1910. Forster, Groom & Co. 3s. 6d.

This book has been written to assist officers in reading for the Special Campaign papers in the promotion examinations to be held next year, and for the entrance examination to the Regular Army in October, 1913, and March, 1914.

The information it gives is put in a concise form.

NAPOLEON'S EUROPEAN CAMPAIGNS, 1796—1815. By Capt. F. W. O. Maycock, D.S.O., The Suffolk Regiment. 169 pp., 23 maps and plans. 8vo. London, 1910. Gale & Polden, Ltd. 5s. nett.

This book gives in a concise form an outline of the European campaigns in which Napoleon himself took a leading part.

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It is clearly illustrated by rough sketch maps of the principal battles, and should prove of service to officers who wish to obtain an idea of the sequence of military events in those days as a preliminary to more detailed study.

ORGANIZATION AND ADMINISTRATION.

NAPOLEON AS AN ORGANIZER (Der Feldherr Napoleon als Organisator). By Lieut. H. Giehrl. 177 pp. 8vo. Berlin, 1911. Mittler. 4s.

Under this heading the author describes the manner in which Napoleon carried out his office work both in peace and in war, his method of issuing orders in the field, the various means he adopted for obtaining information, the importance he attached to maps and map-making, and the measures he took to construct public roads (chaussées) and canals.

The author makes a few comments in the last chapter, and shows how Napoleon's methods must necessarily be modified to suit modern conditions.

The Appendix gives a plan of Napoleon's office and an illustration of the signalling apparatus in vogue in 1795.

ARMY ORGANIZATION AND ADMINISTRATION. By Capt. H. L. Pritchard, D.S.O., R.E. 300 pp. 8vo. Maps and diagrams. London, 1910. Clowes. 10s.

This is not an account or a criticism of any existing system of army organization and administration, but a study of an imaginary system devised by the author.

Starting with the axioms that "the germ of every section of war organization must exist in peace, preparing for war and ready to expand": that "on the outbreak of hostilities there must be no handing over of duties from one department to another, no creation of new branches entirely non-existent in peace": and that "an army is created and maintained for war"; he divides his study into Part i., War, and Part ii., Peace; and in Part iii. examines the application of the principles he advocates to the armies of the British Empire and to the South African War, the defence of India, and small expeditions.

The style is somewhat dogmatic and there is little argument; for instance he says "when we examine Napoleon's methods we find him dealing direct with several men besides Berthier . . . " "The Commander-in-Chief, therefore, divides his head-quarter staff work between five principal officers—of whom the Chief of Staff is one."

In many cases, however, no reasons whatever are given for the proposed arrangement of work.

Roughly his system, compared with the existing British one, to which, however, he does not allude, would hand mobilization and organization from the Adjutant-General to the General Staff. A Department of Communications would take the place of the Quartermaster-General's and deal with transport movements, and "correspondence": by which the author means post, telegraphs, signalling and kindred matters. The supply duties of the Quartermaster-General would be handed over to the Master-General of the Ordnance, re-named the Director-General of Supply and Material. The Inspector-General would become Commander-in-Chief, which office would be revived and combined with that of Minister of War: "It has been shown that command cannot be divorced from administration and financial responsibility"; and "Inspection cannot be divorced from responsibility and power to remedy defects."

"To put the matter in a nutshell: if a nation wishes to fight other nations, it must have an efficient army and to possess this it must have that army entirely controlled by the best soldier (the author does not define the qualities required to gain the right to this absolute superlative), who has a seat in the Cabinet and is War Minister to the Government. If on the other hand a nation is more frightened of its own army than those of foreign Powers, then it will wish to reduce it to inefficiency by refusing money for the army's upkeep, and by appointing a civilian amateur to control it, at the same time making things more difficult for the civilian by placing alongside him a Commander-in-Chief in an anomalous, undefined position without any real power." The author deals with the party and financial objections to having a permanent military War Minister by the argument that "the holder of the purse-strings holds the army . . . as long as Parliament controls the purse, it controls the army."

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POLITICAL.

PEACE OR WAR EAST OF BAIKAL? By E. J. Harrison. 545 pp., 3 maps and numerous illustrations. 8vo. Yokohama. Kelly & Walsh, Ltd. 21s.

The author, a journalist who has resided many years in Japan, has given a singularly impartial account of the conditions in the Far East consequent on the Russo-Japanese War, and the recent Agreements and Conventions affecting the political situation in that part of the world.

The question asked in the title is answered in the first chapter, where the writer gives it as his opinion that peace is likely to last for a decade at least, but that the final struggle for hegemony is inevitable. According to him Japan has no intention of provoking a conflict. On p. 14 he says:—

> "I cannot share the Russian belief that these preparations for war in Korea and Manchuria necessarily imply a resolve to force a conflict upon Russia on some entirely frivolous pretext. Japan on her side has an equal right to assert that the construction of the Amur railway is but preliminary to a war of revenge on the part of Russia against Japan."

The subjects dealt with in the books are:—

Chapters II. and III.—The Russian advance eastwards and the events leading up to it, the net result of which is that "a second Russian armed frontier in the remote east of Siberia from Baikal to the Pacific Ocean, in spite of the economic weakness of that country, has become an inevitable necessity."

Chapters IV. to IX.—East Siberia and a voyage down the Amur river. Vladivostok, the writer says, has improved beyond recognition since the war. It suggests a "live" city more than any other port in the Far East; but, quoting the opinion of Mr. Panoff, a Vladivostok journalist with a lifelong experience of the Far East, he points out the precarious position in which that city would find itself, should the network of railways now being constructed by Japan be completed before the Amur railway. He adds that the Amur railway alone will be insufficient to guarantee Russia against attack. A Japanese advance from Kirin, a town which will soon be connected by rail with Ch'ang-ch'un on the west, and with the Korean port of Chong-jin on the east, in conjunction with a descent upon the Maritime Province, would squeeze Vladivostok in a vice. A fleet strong enough to resist attack from the sea is therefore a vital necessity.

Chapters X. to XIII. deal with Russia in North Manchuria.

Chapters XIV. to XVIII. with Japan in South Manchuria. The writer considers that the enormous vested interests that Japan is building up in Dairen (Dalny) will make it impossible for China to buy her out at the expiration of the lease.

In Chapter XVIII. is discussed the Knox proposal of January, 1910, to neutralize the Manchurian railways. This seems to have left a bad impression on the public mind in Japan. He shows that with a growing population expansion has become a necessity for her, and that, like every other Power, she will expand along the line of least resistance, *i.e.*, Korea and Manchuria. America has always closed her doors to Japanese immigration on the Pacific Coast, and it is not surprising that a proposal from this quarter, which would have the effect of placing her influence in Manchuria on an equal footing with that of any of the six Powers, should have excited bitter feelings in Japan.

Chapters XIX. to XXI.—The Japanese in Korea. Railway projects in Korea are clearly described: the following are likely to be commenced at an early date:—

(1). Mokpo to Koang-ju, in south-west Korea, ultimately to be linked up with the Seoul-Fusan line at Taiden.

(2). Seoul to Gensan. Chong-jin, on the north-east coast, to Hoiryong; thence to be connected with Ch'ang-ch'un by the Kirin-Ch'ang-ch'un railway, now under construction, thus constituting a third line of advance from the sea into the centre of Manchuria.

Texts of recent Treaties, Agreements, and Conventions relating to the Far East are given in appendices.

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There is a good map of Korea and Manchuria. In the railway map of the Far East the portion showing railways in China is misleading. Railways are shown as completed from Tsi-nan Fu and Kiao-chow to Hi-chan Fu (Yi-chou Fu?). This is incorrect. That from Kiao-chow to Yi-chou Fu is projected only, while that from Tsi-nan Fu to Yi-chou Fu is a portion of the Tientsin-Pu K'ou railway, which is now under construction.

STUDIES OF INDIAN LIFE AND SENTIMENT. By Sir Bampfylde Fuller, K.C.S.I., C.I.E. 360 pp., with map and index. 8vo. London, 1910. John Murray. 6s.

Sir Bampfylde Fuller's work is one which should be read by all who take an interest in and are willing to try and understand the real India. Almost every phase of Indian life is touched upon; Indian problems are discussed and explained in a manner which cannot fail to be understood even by those who have not had the opportunity of visiting the country; whilst, at the same time, the wealth of detail and accurate description contained within the covers of the book, are never redundant. The great lesson which Sir Bampfylde seems to convey in this work is that India is not a country inhabited by a nation, homogeneous, compact and self-contained, but a vast sub-continent wherein dwell multitudes of races, differing from each other in every way that it is feasible for human beings to vary from each other. This book possesses the rare merit of accuracy. The reader cannot fail to be impressed with the feeling that he has presented before him the results of a wide experience, close observation and deep study.

STRATEGICAL AND TACTICAL.

CANADA AND CANADIAN DEFENCE. By Major-General C. W. Robinson, C.B. 186 pp., including index. 3 maps. 8vo. London, 1910. Hugh Rees. 6s.

General Robinson's able book will perform good service if it tends to the diffusion throughout the Empire of reasoned information about one of its most important components. One of the principal factors making for closer union of our world-wide Empire is the spread of knowledge of and added interest in the aims, hopes and aspirations of its several parts. In a series of addresses during his visit to Canada in the fall of 1908, Lord Milner pointed out how inadequate human imagination was to enable the separated parts of the Empire to feel acutely the more immediate needs of each other. If there were more books of the nature of *Canada and Canadian Defence* this inadequacy would be lessened, and it would not then be Utopian to hope for a common public opinion upon one at least of our joint problems—the military needs of the Empire.

Unthinkable as is war with the United States, General Robinson points out that Canada must pay a proper regard to the fact that for practically 4,000 miles her frontier marches with that of a powerful nation. His views upon the present needs for the protection of that frontier are based upon the lessons of the war of 1812–14, and he brings in support the opinion of the Duke of Wellington, an opinion which he rightly avers is not greatly affected by the scientific and military advance of 100 years. The outlines of the campaign referred to are set forth in brief and lucid form, lessons are deduced therefrom, and the changes since 1814 affecting these deductions are all carefully considered in the work. In the consideration of these changes and the manner in which they affect Canada's position to-day, much useful information regarding canal and railway construction and general progress in the Dominion is given in enlightening form.

The book contains three useful maps illustrating the events of the war of 1812-14 and the character of a most important part of the Canadian frontier; while Appendix III. contains useful information regarding the harbours and ports of the great Dominion.

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MANŒUVRES PRIOR TO GREAT BATTLES (Vers la Bataille). By Capt. Becker. 138 pp., with 15 maps. 8vo. Paris. Berger-Levrault. 6s. 3d.

Although this book contains no original ideas, it is a good summary of the present French ideas on strategy. After a lengthy preface, in which the necessity of thorough national preparation for war is insisted on, the author discusses such subjects as the strategical plan, *rôle* of cavalry, operations of a covering force, strategical advanced guard, concentration, etc. He deals mainly with the probable actions of a Franco-German war, and gives numerous examples from military history, although, like many other writers, he is apt to strain facts.

TRAINING AND EDUCATION.

MILITARY LAW. By Major T. King. 72 pp. 8vo. London, 1910. Forster Groom. 2s. 6d.

This is a book of questions and answers on military law, arranged to assist officers in working up the subject for examinations.

TRAVEL AND TOPOGRAPHICAL.

MAP TO ILLUSTRATE THE INDIAN MUTINY, 1857, WITH NOTES AND REFERENCES. London, 1910. Forster Groom. 2s. 6d.

This publication is one of the "Whitehall Series of Military Maps," specially produced for Military History Examinations. It consists of a folding map of India, showing the communications and garrisons as they were in 1857, with an inset showing the present Indian railway systems. Three pages of notes on the Mutiny, giving a general *résumé* of the whole situation, are attached to the inside of the cover. The notes include a few observations on the lessons to be drawn from the operations. Small flags to assist the student to mark the dispositions of the forces during the campaign are contained in an envelope enclosed with the map.

The work will be of assistance to the student of Military History.

CORRESPONDENCE.

BRIDGING AT HARTY FERRY.

SIR,

Since writing the notes on the above, which appeared in the February number of the *Journal*, I have learned that the method of placing a number of trestles simultaneously in bridge, devised at Harty by Capt. Sankey, R.E., to suit the local conditions, had already been tried in Ireland at Athy by the 17th Company, R.E., earlier in the same month. In this case the method was thought of and marked out by Lieut.-Colonel J. A. Tulloch, R.E., and Lieut. E. B. Fox, R.E., with successful results.

I am, Sir, etc.,

J. C. MATHESON,

Major, R.E.

Chatham, 14. 2. 11.

The Editor, *R.E. Journal.*

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MOTOR CAR IGNITION SYSTEMS.

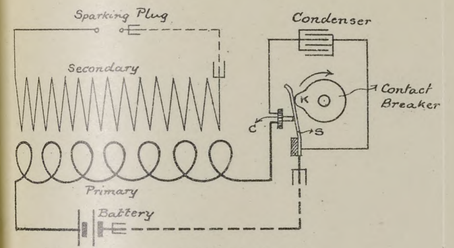

FIG. 1.—*Battery and Coil—Non-Trembler.*

FIG. 5.—*Type of 4-Cylinder Contact Maker.*

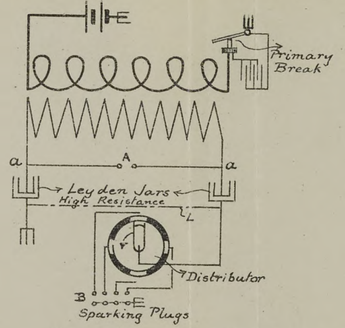

FIG. 8.—*Lodge High Tension Coil.*

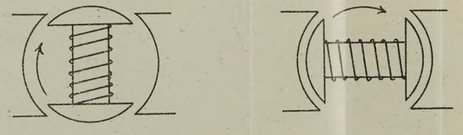

FIG. 11.—*Theoretical Positions of Armature at Moments of Zero and Maximum Current.*

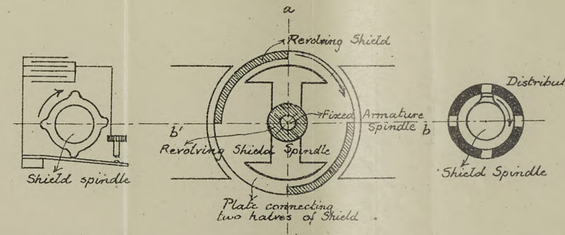

FIG. 14.—*Revolving Shield H.T. Magneto (Windings not shown).*

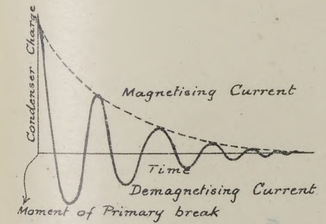

FIG. 2.—*Oscillatory Discharge from Condenser.*

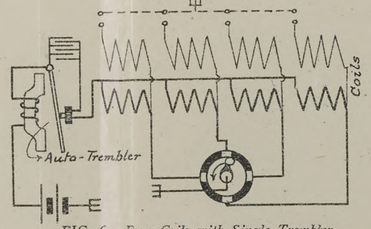

FIG. 6.—*Four Coils with Single Trembler.*

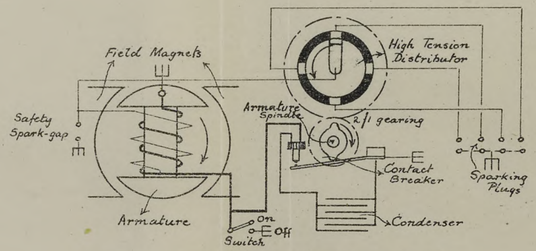

FIG. 9.—*Circuits of Typical High Tension Magneto.*

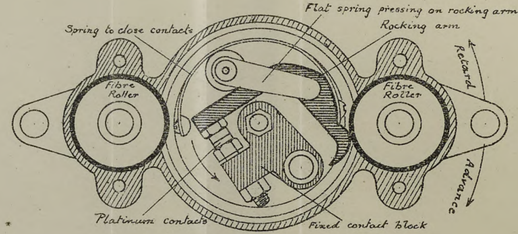

FIG. 12.—*Type of H.T. Magneto Contact Breaker.*

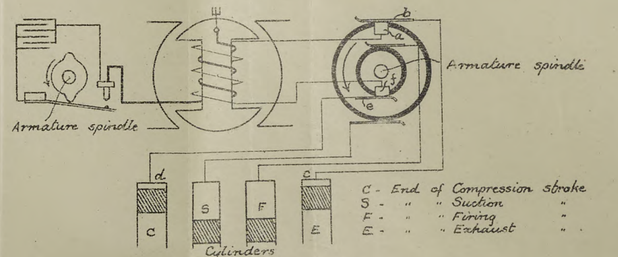

FIG. 15.—*Circuits of Nieuport Magneto.*

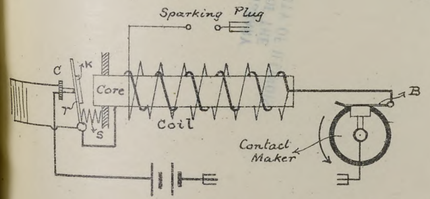

FIG. 3.—*Battery and Trembler Coil.*

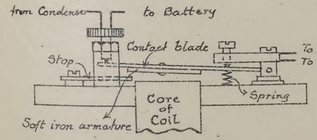

FIG. 4.—*Trembler.*

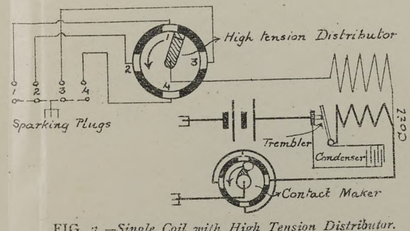

FIG. 7.—*Single Coil with High Tension Distributor.*

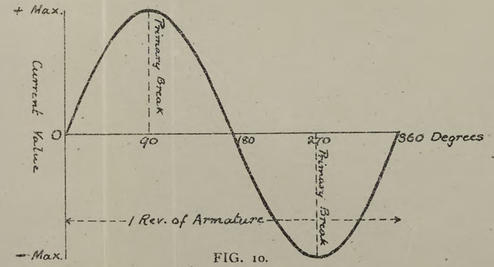

FIG. 10.

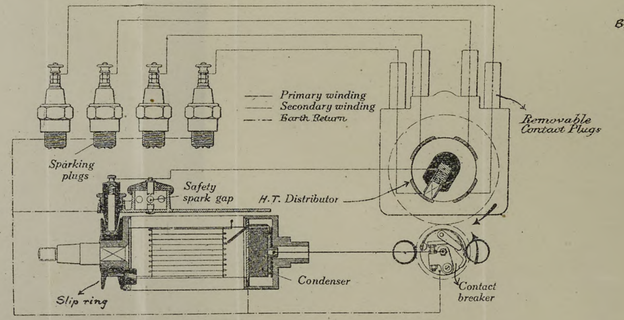

FIG. 13.

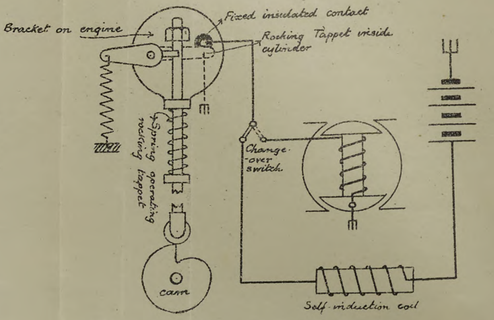

FIG. 16.—*Low Tension Battery and Magneto.*

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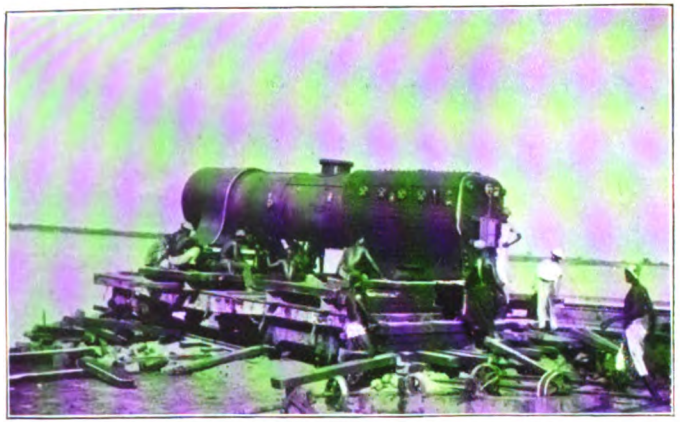
BARO-KANO RAILWAY CONSTRUCTION.



Jacking Heavy Boiler between Truck and Barge.

Falsework for erection of 100′ Span Bridge.

over a Washaway Gap.

Overturned Emir Engine.

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Discharging a Heavy Boiler at Baro.

Baro Beach during 1908 Shipping (showing arrangement for handling Wagon Bodies).

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BARO-KANO RAILWAY CONSTRUCTION.

By Capt. H. O. Mance, d.s.o., R.E.

Prior to the construction of the Baro-Kano Railway, the sole means of communication over all portions of Northern Nigeria not immediately served by the Niger or navigable portions of its most important tributaries, the Benue and Kaduna, was by native tracks, over which all stores had to be conveyed by head transport. These tracks were for the most part impracticable in the height of the rainy season, and at the best of times 15 miles was considered a good average day's progress. It became evident several years ago that further development of this colony was impossible without improved communications, and the matter came into special prominence, when the investigations of the British Cotton Growing Association brought to light the fact that Northern Nigeria was the most promising field for the production of cotton to meet the expanding requirements of our most important textile industry, now threatened with shortage of raw material owing to the increasing proportion of American-grown cotton required for American mills. In addition to the necessity for a cheap outlet for the products of the country, efficient administration was most difficult and costly, and there always remained the strategic difficulty of coping with any native rising with the small forces available under the existing adverse conditions of transport and personal travel.

To these primary considerations must now be added the discovery of a rich tin field in the region of Bauchi, some 140 miles east of the railway under construction.

A large amount of official correspondence had taken place on the subject of Nigerian Railway Construction, and a survey had been made from Baro to Kano *viâ* Zungeru before 1907. Various schemes were put forward, and after consideration a 3′ 6″ gauge line was recommended over this route with a maximum gradient of 1 in 50. In May, 1907, Sir Percy Girouard, Governor of Northern Nigeria, formulated a railway policy in which he recommended the construction by the Public Works Department of the Protectorate, of a 3′ 6″ gauge railway from Baro to Kano, avoiding Zungeru, the present capital, the site of which ceases to be of importance as soon as a more efficient channel of communication than the Kaduna River becomes available. As the result of a survey, superintended personally by Sir Percy Girouard, it was found possible to adopt a ruling gradient of ·7 per cent., or 1 in 143, for traffic going up country, and

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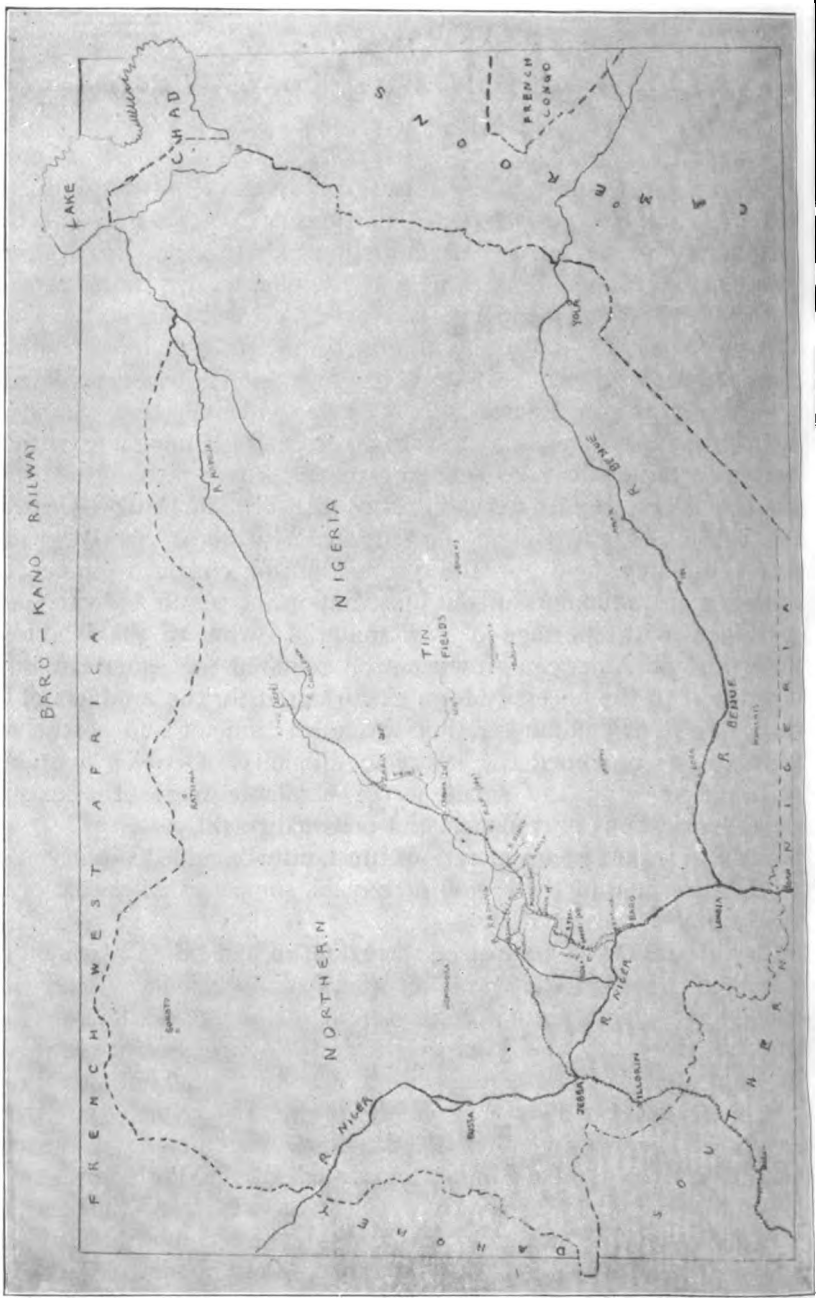
MAP OF NORTHERN NIGERIA SHOWING BARO-KANO RAILWAY.



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·6 per cent., or 1 in 166, for traffic coastwards throughout the first section of 111 miles. Construction was authorized in August, 1907, and 10 miles of permanent way material were at once sent out. Thanks to very careful preparation and to the organization of all the resources locally available, a full programme of work was carried out during the dry season 1907–8, thereby probably saving a year in the time required to complete the railway to Kano. An absolutely free hand has been given to the man on the spot as regards all engineering details including the alignment. Without this such cheap and rapid construction would not be possible. It has also been decided to link up the Lagos Railway with the Baro-Kano line by extending the former through Jebba and Zungeru to Minna.

The Niger in Jebba flows in two channels, one of which is now being bridged, and the other will be traversed by train ferry till the traffic justifies the building of a bridge.

The portion from Minna Junction to Zungeru has already been laid, and railhead of the Lagos extension is about half-way from Jebba to Zungeru. The road bridge over the Kaduna at Zungeru is being strengthened and altered to carry the railway, and it is hoped that the systems will be linked up early next year.

Baro, the Niger terminus of the Baro-Kano Railway, is situated about 420 miles from the coast. At high water from the beginning of August to the middle of October, it is accessible by steamers drawing from 9′ to 12′ and containing up to 1,100 tons of cargo. For the rest of the year boats drawing 4′ have no difficulty in reaching Baro, except for the months of April, May and June, when a draught of 2′ is all that can be reckoned upon. It was found, however, that there were only about 2 miles of shallows to be dredged to make the river available for vessels drawing 4′ throughout the year, and that only some 5 miles of shallows stood in the way of a 6′ channel all the year round. A powerful suction dredger has therefore been obtained, by means of which it is hoped to maintain a channel for vessels drawing at least 4′, and it is a hopeful sign that the very small amount of work which was done by this dredger during the recent especially low river, enabled the larger stern wheelers to work regularly up to Baro for the first time. With an available draught of 4′, all traffic likely to pass over the Baro-Kano Railway for some time to come during the low river season can be easily handled by tugs capable of towing two barges each with a capacity of 100 tons.

Delivery of Material at Baro.

In view of the very rapid rate of progress on which the estimates for the construction of the Baro-Kano Railway were based, the serious question arose as to whether it would be possible to deliver

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at Baro, during the high river, the large quantity of material required for a whole year's programme. Some difficulty had been experienced, owing to an exceptionally low river, in delivering by three large steamers (commonly known as "branch boats"), supplemented by stern wheelers, the 3,000 tons required for the 1907–8 programme, and the estimated tonnage for 1908 high river was 23,000, and for 1909 nearly 30,000. The possible causes of failure were many, and it was freely predicted that the programme would have to be considerably amended for this reason. The unfortunate early experience of the French on the Senegal River under somewhat similar circumstances showed clearly how serious might be the consequences of any miscarriage. Thanks, however, to the careful co-operation of the shipping firms, and to favourable high river seasons in 1908 and 1909, all these fears have proved to be groundless.

The appliances for dealing with railway material on arrival at Baro were of the most primitive nature. All that could be done in the time was to provide sufficient stacking ground—no easy matter on such sloping ground—and to obtain a number of 12″×12″ timbers about 50′ long for employment as gangways from the branch boats to the shore. When the first steamers arrived the level of the water was such that a steep pull-up was involved, but later on this disadvantage ceased to exist. An unlimited amount of absolutely unskilled labour was made available, and from 22 to 24 European foremen were detailed at Baro for the work of dealing with the first year's shipping. Of these foremen, 9 were Royal Engineers, and 16 in all were quite new to the country. Under the circumstances it was only possible to employ the most rudimentary methods, and for the first day or two progress was decidedly slow. It was found best to employ about 60 to 75 natives at each hatchway, and at first it was necessary to employ a foreman at each hatchway and one on the stacking ground for each ship, but the latter was dispensed with after the first fortnight. Two shifts were worked, the first being 6 to 8.30 and 9.30 to 3 p.m.; and the second 3 p.m. to 7 p.m. and 8 p.m. to midnight. A number of Kitson lights were provided for night work. They were found to be rather delicate and to require a skilled European mechanic in charge of them, but otherwise answered the purpose most excellently except actually during tornadoes. An acetylene flare light, however, has since been tried, and it appears to offer considerable advantages on account of its strength and simplicity. Work was carried out on Sundays, usually one shift only, but it was found necessary to arrange for every European and gang to have one day a week off the works.

Discharging Rails.—The procedure for discharging rails was to slide them in bundles of from three to ten, depending on the slope up to the bank, across a gangway consisting of two of the long timbers mentioned above spaced at about 15′ interval, each of them

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having rails spiked along their upper surface and kept thoroughly greased. A hauling rope was fastened near each end of the bundles, and, with a little practice, the gangs on shore got in the way of keeping the bundle central with reference to the two timbers, or of adjusting any tendency to move aside or come up skew-ways. On the arrival of each sling at the bank, carrying parties were awaiting in sufficient strength to take the rails to the stack beds at once, as an accumulation of more than a few rails on the bank resulted in impeding the work. The rail stack beds were most carefully prepared, the type usually employed consisting of four rail lengths of track side by side, the whole of the sleepers being carefully packed quite level. Owing to lack of space it was found necessary to have full layers in both directions throughout the stack, which was raised to a height of 13 layers, or about 4′ 6″. Separate stack beds were provided for "special" rails and for the percentage of shorter rails from 18′ upwards, and it is important to separate out all bent rails and stack them separately for subsequent straightening. A simple form of rail hook, made out of $\frac{3}{8}$″ iron and about 2′ long, was found very convenient for handling the rails on the stack beds. Care must be taken that the ends of the rails are not burred by blows from a hammer.

Discharging Sleepers.—Sleepers were carried ashore on gangways and can be stacked on almost any ground. Where space admits it is quicker and more economical to throw them into piles. Time is also saved when re-loading, as sometimes two or three sleepers in a proper stack, jamb together and have to be separated by a bar.

Handling Heavy Cases.—Owing to the lack of facilities, the discharging of cases weighing from 2 to 30 cwt. was a source of much trouble, two or three handlings being sometimes necessary and the cases having occasionally to be broken up on the beach. The best way of dealing with these would be by a quick-acting steam crane direct into trucks. It is well worth building for the purpose, a small jetty capable of receiving a lighter alongside, and to arrange for all such cases to be delivered from the steamers into lighters.

Handling Heavy Locomotives.—The most difficult problem was the discharging of the boilers, frames and tenders of the locomotives. These weighed up to 12½ tons, and the first consignment had to be got ashore from an insecurely moored steamer, over a clear span of 42′, then up an incline of 1 in 2 for 30′, along 40′ of level, and finally lifted on to trucks. The only power available was one of the ship's winches, and less than a foot was available on board to receive the ends of the gangway timbers. The shore was reached by a gangway of four heavy timbers with rails spiked on top, the outer timbers having to be spaced only 9′ apart to fit the gangway of the ship. A cradle with smooth metal under surfaces was constructed to slide on

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this gangway and provided with flanges at 9′ gauge. The heavy weights were carefully balanced on the centre of the cradle, to which they were lashed with wire rope. Large sheerlegs were erected on shore, 12″ × 12″ timbers over 50′ long being employed, and steel rope lashings and tackle throughout. The sliding track was continued from the gangway up to the sheerlegs, under which a siding was laid. The cradle was pulled from the ship's side to the siding by the main tackle of the sheerlegs, the angle of attachment of the sling which was passed round the cradle, and its weight, being arranged with very great care. As the blocks available for the first weights were much weaker than the rest of the tackle, every precaution had to be taken to avoid hitches which might bring indeterminate strains to bear, and a vital point to bear in mind is the disturbing effect on the ship's moorings, caused by the use of the ship's winch for the main tackle of the sheerlegs. The use of steel rope lashings and tackle for sheerlegs required to lift regularly from 10 to 20 tons, is strongly recommended. The second consignment of heavy weights was dealt with in a similar manner without any difficulty as stronger tackle was available, and owing to the higher river the clear span and steepness of the slope were much reduced. In 1909 the heavy weights were loaded direct into trucks from the steamers at a jetty erected for the purpose.

Wagon frames, which weighed about 2 tons, were transferred from the ships to the tops of lighters and slid off on to carefully prepared stacking beds, from which they were later on slid under a derrick for erection.

General.—In dealing with large quantities of material, as above, the secret of success is to look well ahead in the preparation of sufficient stacking beds, to insist on the economical use of the ground, and to be on the *qui vive* to repress the inevitable tendency of the carriers to get rid of their loads at the earliest possible moment, and, by thus effectually blocking the entrance to the stacking ground, to very seriously retard the operations which may have to be temporarily suspended to put matters right.

Arrangements were made to deal with three branch boats at a time. After the first few days it was found possible to deal with 500 tons a day with ease, and on August 31st a maximum of 870 tons was attained. The quickest boat averaged 355 tons a day for two shifts, or 25 tons per hour of actual work. The total number of natives employed at this time was about 1,200. A dressing tent on the site of the work saved a lot of time in dealing with minor injuries. Almost incredible to relate, in 1908 over 20,000 tons of material were handled with absolutely raw labour, with only one serious accident which necessitated the amputation of a foot.

As regards the cost of handling, it was found impossible to analyze each class of work at the time, but, with foremen costing £1 a day and native labour at 9d., there should be no difficulty in handling rails

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and sleepers at 1s. 2d. a ton, including the preparation of stack beds, stacking, and the clearing-up operations frequently necessary after the periods of greatest stress.

Discharging Locomotives from Lighters.—After the high river, some locomotives were sent up to Baro in lighters, and proved an awkward task to discharge as the banks were very high at this time, and the barges had to be lightly loaded to reduce the draught. The procedure was to jack the weights high enough above the level of the barge to allow a gangway to be inserted underneath them together with the cradle referred to above. The weights were then pulled up a very steep incline in the same way as before, with the exception that an insufficiently powerful winch had to be employed for the main tackle. As this winch had no capstan drum, three separate lifts had to be taken before the weights were deposited on the trucks. For this purpose, and to guard against accidents, safety ropes were invariably provided and kept tight, a most useful precaution in view of the fact that the cylinder cover of the winch blew off on one occasion. The most serious difficulty in off-loading from lighters is due to their instability, as any deviation of the weight from the centre made them heel over badly. It is well worth while rigidly lashing a second barge alongside.

At a certain level of the river it was found possible to use an existing slipway, and to arrange to traverse the heavy weights by jack direct from the barge to the truck over intervening staging.

Plate-Laying and Ballasting.

The Baro-Kano Railway is being constructed as a pioneer railway, that is to say, the expenses of construction are cut down to a minimum, consistent with obtaining a railway capable of carrying all traffic in connection with the administration of the country, and such trade as is likely to develop during the first years of its existence. This economy has not been allowed to affect the most efficient grading and alignment, so that it will be possible as the amount of traffic justifies it, to gradually strengthen the line and improve the accommodation to meet the requirements. One very considerable source of economy is in the ballasting, which is carried out with sand or any other suitable material available in the immediate vicinity of the line. It is only over a few comparatively short lengths, where the surrounding soil is entirely clay or black cotton ground, that ballast has to be brought by train. This saving in the actual cost of haulage is supplemented by the important reduction in the amount of rolling stock necessary for construction, a point of the highest importance. The extra cost of obtaining better ballast at the expense of a longer lead up to half a mile or even a mile, is well worth incurring, but it may be found in rapid railway construction that shortage of labour may

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prevent full weight being given to this consideration. Ballasting was placed under the officer in charge of the Plate-Laying District, and was carried out only a few miles in front of railhead.

Procedure.—The procedure of ballasting and plate-laying is as follows:—

The formation is trimmed up by the earthwork parties and the line is re-centred with pickets left standing about 3″ above the surface. At the same time level pegs are given every two hundred feet on the straight, and every one hundred feet or even fifty feet on curves. These pegs are best driven on the edge of the formation flush with the correct formation level, and marked by reference pegs painted white, two such reference pegs being used at each change of grade. This re-centring and levelling is of the greatest importance, as the quality, rapidity and cost of the work, depend on the track being laid absolutely straight and as nearly as possible to correct levels in the first place. Next come the ballasting parties who make a platform of the best material available 8′ wide on the top, with the surface on straight portions of the line 7″ above correct formation level. In this way an accurately graded surface is prepared for track-laying, notwithstanding slight irregularities in the formation. In the centre of this platform there is left a **V**-shaped groove or furrow (to which fact this ballast platform owes its local name of "the furrow") for the purpose of leaving the centre pegs exposed to view, and at the same time guarding against any chance of the centre of the sleeper being packed higher than the ends. Accuracy of the grading and alignment of the furrow is obtained by putting in side pegs every 25′ to mark the outer edges of the furrow, these pegs being levelled to the exact height by boning from the formation pegs. One European with from six to ten locally trained natives has no difficulty in doing from 1½ to 2 miles of this boning in a day. On curves the furrow is correctly super-elevated, the point under the inner rail remaining at the height of 7″. In this way the road is safe for construction traffic immediately after track-laying, a large amount of lifting is saved, and the extra quantity of ballast required is provided for. The section of the furrow is calculated to provide the requisite ballast for a correct lift to formation level, additional ballast being required for very low places or boxing in.

Track-laying is carried out directly from the construction train, which is pushed by the largest engine which it is safe to allow over the line. The material is loaded up in units of two trucks containing one-fifth of a mile of material complete. The bottom layer of rails in the rail truck rests on three or four transverse sleepers, and each layer above on thin strips of packing which is broken up as the truck is off-loaded. It is important that no bent rails or short "specials" are loaded up with the ordinary rails, as these delay the track-laying

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and are expensive and troublesome to pick up. The sleepers are carried from 100 to 200 yards ahead of the train and thrown down across the furrow. Here they are roughly spaced at an even distance of 2′ 6″ centres, by a few natives provided with gauges. This ensures the correct number being left per rail length. The centre of each sleeper is at once marked ready for the sleeper straightening and spacing party, consisting of about six natives provided with a special 90′ chain, the links of which are exactly the length between the centres of the sleepers. This chain is stretched along the centre pegs and held by a boy at each peg, and the sleepers are accurately spaced, centred and squared to the chain by a trained head boy. It may here be mentioned that the weight of rail is 45 lbs. per yard, and that 12 steel sleepers (weight 72 lbs.) are used for each rail length and spaced 2′ 6½″, except at the joints which are 2′ 0½″.

The natives of Northern Nigeria carry all loads on their heads, and find considerable difficulty in picking up heavy weights from the ground. The work of rail carrying was, therefore, enormously expedited by the expedient of inserting short lengths of rails as cantilevers under the bottom layer of rails on the truck, and sliding the rails on to these cantilevers so that the carriers could take them directly on their heads. This expedient also avoids the tendency of rails being left behind when the construction train moves forward. The rail-carrying gangs vary from 8 to 10 men. For continuous work, especially when laying through deep cuttings or over high banks, it does not pay to cut down the gangs to less than 10. The number of linking-in rail gangs depends on the rate desired. If over ½ mile a day, a special gang lifts the rails and places them on the sleepers as near as possible in position, so that the gangs inserting the rails have less to do. The latter operation is carried out with the assistance of about six thin-pointed crowbars for each gang. The rails are next butted against the expansion irons (these are ⅛″ thick, hot weather midday; ¼″ hot weather morning, cool weather midday; ⅜″ cool weather, morning) and fished with two bolts. After three or four rail lengths the track is straightened to centre pegs, the sleeper spacing checked, and the train signalled forward. The remaining two fish bolts and all the keys are put in later on, sometimes two or three weeks behind railhead, though it would be better to follow close behind. Within 5 miles of railhead should follow the first lift party, and these leave the track accurately packed straightened and graded at the final height of 12″ above formation level. It will be seen that accurate pegging out, ballasting and track-laying will greatly facilitate the work of this party, who should have no difficulty in averaging ½ mile a day, including boxing in, for each party consisting of 1 European and 150 natives. The track is then fit to run over at 30 miles an hour, except over special places such as deviations. A few small maintenance gangs should work on the section immediately

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behind the construction train to deal with slacks on the newly-made banks, put in points and crossings, and attend to bridge approaches and deviations. During the dry weather it is possible for several weeks to run over the track just as it is left by the construction train, and it is wonderful how the line holds up under these conditions with good sand ballast.

On curves, special rails 29′ 8″ long were used at first to keep the joints square. Owing to a shortage in these, joints on curves were staggered by starting with an 18′ rail on the outer side just before entering on the curve, and finishing with a closer, just after the end of the curve, to bring the joints square again. No time is lost cutting the closer which is fly fished for the time being. Except for the disadvantage of the irregular spacing of sleepers, there is no doubt that the staggered joints resulted in a better running track.

The usual working hours at railhead were from 6 a.m. to 3 p.m. with an interval for breakfast at an hour depending on the progress of the work, but if possible before 10 a.m. In the hot weather in the Bako Valley these hours were slightly curtailed, and work started at 5.30 in the morning. The Europeans of the construction party were accommodated in type camps from 5 to 10 miles apart, the houses being mud or grass, supplemented by tents. It is difficult to get work done on the day of changing camp, and it very often pays to reconcile oneself to losing a day, or to make it fit in with pay-day. It is most important that camps should be kept thoroughly clean, and an expenditure equivalent to £1 10s. per mile was freely incurred with this object.

The *labour question* has hitherto been a most serious one. Some 15,000 natives were employed on the Baro-Kano Railway from January to March, 1910, and in a new country it is not easy to procure this number. Moreover, during the past season work has been carried on through large uncultivated areas, and the question of food supply has added to our difficulties. Markets were established at Railhead Camp, free passes were issued to traders bringing supplies to railhead, and rice was imported and issued at cost price. Weekly payments were found necessary to give confidence to the natives, and the arrangement of this, including the supply of specie from Baro, gave endless trouble.

General.—A covered tool truck is kept at Railhead Camp, and saves a lot of trouble and loss in view of the frequent moves as railhead progresses. A native blacksmith and a few native carpenters are required at railhead. The latter, besides attending to miscellaneous jobs, make from local timber all the pick and hammer handles used at railhead, and also all the wooden beaters used with sand ballast in preference to the ordinary form of steel beater.

When out of touch with the European doctor, a European medical orderly is attached to railhead, and in any case a native dresser to

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attend to minor injuries and ailments among the labourers which would otherwise throw a lot of extra work on the engineer in charge. A canteen truck is arranged for at railhead, through one of the Baro firms, and is found a very great convenience.

It is most important that railhead should be in good telegraphic or telephonic communication with stations behind and headquarters. With this end in view, the advanced telegraph station was kept pushed forward to the railway station nearest Railhead Camp. A telegraph line was laid by a construction party attached to railhead and had no difficulty in laying 2 miles a day. Great trouble was experienced through breakdowns caused by lightning and by bush fires.

Rate of Progress.

Plate-laying was started on the 22nd October, 1908, railhead at this time being at miles 6¼, the remainder of the 10 miles sent out in 1907 being required for Baro Yard. For the first few days, from 100 to 150 raw natives only were employed, and the whole attention of the Europeans was devoted to instructing the gang in the rudiments of the work. For example, it took three or four weeks before the head man of the sleeper spacing gang could be relied on to leave the sleepers square with the sleeper chain. On December 30th, with 296 labourers, 1 mile was laid for the first time, and it was only because track-laying caught up the earthwork and culvert parties that the maximum of 1¼ miles was not exceeded during the first season. On resuming track-laying in November, 1909, 1 mile a day was done during one of the first weeks. In March, 1910, the main track-laying party laid 22 miles of main line over 15 bad deviations, and 2 miles of sidings with 11 sets of points and crossings. But for various delays not connected with the railhead party, and which checked the work on 11 days, another 7 miles might have been laid. In one week of this month 6·4 miles were laid and camp shifted, the best day being 1⅗ miles over two of the worst deviations on the line. To carry out this work a good deal of night running had to be undertaken on the advance section with the largest engines available. During the early part of this same month a second plate-laying party laid 9 miles on the Zungeru branch line, and afterwards cut out several deviations, bringing the grand total for the month up to 37 miles. On February 25th, with 450 natives, Lieut. Maxwell laid 2⅗ miles by 4.15 p.m., when all the available material was finished, and on the same day just over 1 mile was laid by the party on the Zungeru branch. A table is given showing the monthly rates of progress for the two first plate-laying seasons.

During the second season the grand total of track laid, including sidings and temporary work, was 165 miles, an average of 24·65 miles per month having been maintained for 6½ months. Taking Lieut.

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Maxwell's plate-laying party alone, the total laid in 6½ months was 130·4 miles, which works out at 20·1 miles per month. The progress of this party on the main line only, was 123·4 miles, which gives an average of 19 miles per month. The last 17 miles into Zungeru was laid between the 3rd and 19th of May in 17 days; notwithstanding 4 days' complete or almost complete stoppage of work, the average amount laid on the 9 days on which no delays were experienced was 1·44 miles per day.

CAUSES OF DELAY.

I will now deal with the principal causes which resulted in delay to the railhead party :—

1. *Lack of Labour.*—As there was a general shortage of labour, the amount available had to be proportioned so as to ensure an equal rate of progress by the earthwork, culvert, plate-laying and bridging parties. A large proportion of the labour was recruited in gangs by arrangement with the native chiefs who changed them at intervals, the result being that the Europeans had to start again the work of instruction. The actual linking-in gangs however were permanently engaged.

2. *Minor culverts* were put in ahead of the track, and it was found advantageous not to put in the deviations too far ahead of the track. During the last season the plate-layers kept on the heels of the preceding parties and experienced several checks. On one occasion, at a deviation, the earthwork ballasting and plate-laying parties were all working within a distance of 200 yards.

3. *Deviations.*—Up to 15 of these were crossed each month. Owing to the impossibility of starting the construction engine on the up grade, each deviation necessitated a long carry for the rails and sleepers. Moreover, newly-made deviations with high banks are a source of great anxiety, and it is frequently necessary to interpolate wood sleepers between the steel ones over the softest places. During the wet season these deviations must be taken slowly, and the only way to do this is by considerably reducing the loads of the trains. On one occasion at a bad sag under the weight of the train, the buffers of eight wagons and one break van became interlocked, but the driver had the presence of mind not to stop the train, and averted a derailment. A more serious matter was the sudden collapse in the middle of the dry season of a newly-made deviation bank, resulting in one of our largest engines turning right over. Luckily nobody was hurt. The breakdown operations occupied less than a fortnight, and the engine was running regularly within five days of being re-railed. The driver, 2nd Corpl. Marriner, R.E., behaved very pluckily.

4. This brings me to the increasing difficulty of track-laying as the wet season approaches. Gradually the heavier engines have to be

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taken off the newly-laid track and the maintenance officer, who desires to postpone this cause of delay as long as possible, has an anxious time of it, especially if through shortage of labour the first lift party are several miles behind railhead, in which case also the cost of maintenance is higher. Eventually a few serious settlements of soft banks give a warning which cannot be disregarded, and railhead has to be kept supplied as best possible by the smaller locomotives, which have also to be employed on ballasting the worst places.

5. *Lack of Material at Railhead.*—Once the plate-laying party has been thoroughly organized and a clear run is open to them, the limiting factor in the rate of progress is found to be the supply of material to railhead. On account of the limitations caused by other sources of delay, this particular difficulty has not hitherto come into the prominence which it is expected to reach next season, where the lead starts at 215 miles. This result has been largely due to the splendid work put in by the engine drivers, both civilians and R.E., whom we have been fortunate enough to secure. In the event of material not being forthcoming on any particular day, the delay was frequently averted by taking the weekly day of rest on that day.

6. For the first 20 miles of track-laying the permanent bridge trestles were built in advance, and railhead was held up at each bridge while the stringers were placed in position. This practice was not found conducive to rapid or economical plate-laying, as with cheap labour the cost of deviations is comparatively small and will be saved in the cheaper track-laying and transport of bridge material.

7. In the earlier days, portions of incorrectly levelled formation, due to the rawness of the earthwork parties, caused considerable trouble to the ballasting parties, themselves consisting of untrained gangs, and the plate-laying parties were handicapped by an uneven platform to lay on.

8. Hitches in connection with timekeeping, shifting camp and pay, will occur unless the officer in charge keeps a careful watch on these matters.

9. A new gang at the base may result in several trucks of material being sent out badly loaded to rail head.

10. Temporary water supply for locomotives has to be arranged for, and very often it is found impossible to erect tanks as early as desired. In any case the railhead engine will require a tank truck. In the tropics it is best to use steel piping even for temporary work, though sufficient hose and couplings should be kept at railhead for emergencies. It is important to arrange for interchangeable couplings between the hose and the steel piping.

11. In the wet season work is occasionally entirely interrupted by washaways at deviations, or at unfinished culverts in places where it has been found expedient to fill in the bank temporarily. In this

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case all available gangs are concentrated on re-establishing communications.

12. The wet weather again is responsible for bad steaming of locomotives with damp wood fuel, wood being used as much as possible to save the transport of coal.

13. An occasional derailment adds to the variety of the work, which even under the best circumstances can hardly be rated as monotonous.

All these delays were generally counteracted by working overtime.

LABOUR FOR PLATE-LAYING.

The following is a statement of the amount of labour found necessary at railhead and for the first lift, to work at the rate of 25 miles a month.

Ballasting party	350 to 400	
Linking in	250 to 350	
Keying	45	
Points and crossing and maintenance at railhead	70	
First lift	300	(in 2 parties).
Woodcutting	35	
	1,200	

Cost.—The cost of the work at railhead depends on the delays experienced, on an average they work out as follows :—

Boning	£3 to £4	per mile.
Furrow	£12 „ £18	„
Linking in and keying ...	£22 „ £30	„ (generally nearer the lower figure).
Miscellaneous	£8 „ £25	(the latter figure includes maintenance for 30 miles behind railhead).
First lift	£16 „ £20	

These figures include the salaries of the Europeans with their passages and proportion of pay and leave, pay of boys and all other expenses at railhead, except the cost of rail transport, which is debited to another subhead.

The item "Miscellaneous" includes pay and allowance of officer in charge and clerical staff, pay of mechanics, pay of Europeans while on the sick list, temporary water supply, points and crossings, maintenance in front of first lift, and incidental work done on days when railhead is checked.

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1910 TO 1911 PROGRAMME.

In the approaching plate-laying programme the limiting factor will undoubtedly be rail transport. As the quantity of rolling stock required during construction is far in excess of what is necessary for the first year of open line working, the amount purchased for construction should be the minimum which will suffice with careful organization, to carry out the allotted programme.

In view of the fact that work at railhead does not continue throughout the whole year, the off-season is utilized for bringing up rails and sleepers from the base to one or more advanced depôts, thereby reducing the lead and increasing the rate of delivery at railhead when the plate-laying starts. The cost of the extra handling of the material is quite insignificant compared with the saving effected in the amount of rolling stock necessary.

Owing to a very late river, we shall also be faced with the difficulty of transporting from Lokoja to Baro some 3,000 tons of material which was discharged at Lokoja before the river had risen high enough to allow branch boats to proceed to Baro. Being also the last year of the work, the greatest care will have to be taken to pick up all material lying along the line or in temporary work, and also to straighten a large number of rails bent in transit (this item alone will amount from 10 to 20 miles) in order to make quite sure that the material will be available for the last few miles into Kano.

The last section is a particularly easy one as regards bridging and culverts, and labour and food are very plentiful, so that no difficulty is anticipated in getting the formation ready ahead of the plate-laying party, and the plate-laying and maintenance parties if provided with the labour asked for (1,200 boys gradually increasing to 2,000) should easily cope with all the material that the traffic department can supply. Arrangements are being made to complete 25 miles of culverts and of furrow before the commencement of the next plate-laying season.

There remains the difficulty of water supply, and attention is already being devoted to forestalling this. The ruling gradient which is 1 in 60 compensated in both directions from Minna to Zaria is reduced to 1 in 80 from Zaria to Kano.

On account of lack of space I propose to touch only lightly on the earthworks and bridging of the line.

EARTHWORKS

cost from £200 to £340 per mile, though, in a few places where there was very heavy work, the cost reached £800 per mile. The rate of progress has been from 15 to 26 miles per month. The cost of the work from 3½d. to 4½d. per cubic yard.

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Rock cuttings have been carefully avoided, but heavy work has been faced to obtain a better ruling grade with a view to the best ultimate efficiency of the line.

BRIDGING.

Bridging on the first two sections, namely up to the Kaduna, has had to be very heavy for a pioneer line. The waterways amount to 50 lineal feet per mile on the Baro-Minna Section. The largest bridge will be about 500′ long over the Kaduna. The largest span employed is the South African type of 100′. In the first section practically all the foundations are in sand and consist of wells sunk up to a depth of 20′. The expedient of using concrete well curbs reinforced with a few train rails was found to be most successful. With one exception, where a powerful steam pump was used, the foundations were kept clear of water by diaphram pumps. It is vital to get all the foundations in before the first heavy rains, and towards the end of the dry season the work on the piers and superstructure is practically neglected till all these are secured.

Steel trestle piers are used for spans up to 30′ and can be very quickly erected. The commonest spans are 15′, 20′ and 30′. The bulk of the culverts are thick corrugated iron, 2′, 3′, 4′, 5′ and 6′ diameter, the weight being relieved by dry stone walls with a concrete arch or a platform of rails and stones, in the case of all culverts over 3′ diameter. A number of thick steel culverts 6′ diameter have also been employed.

LOCOMOTIVES AND RAILWAY STOCK.

The rolling stock available on the Baro-Kano Railway during the second plate-laying season was as follows :—

5 engines known as the "Emir" class (eight-coupled with leading bogie, and weighing with tender 74 tons loaded).
2 eight-coupled tender engines with leading poney, weighing about 62 tons.
2 six-coupled tender engines with leading poney.
2 six-coupled tender engines with leading and trailing poneys.
3 shunting engines, six-coupled weighing 22 tons.
2 small six-coupled shunting engines weighing 15 tons.

16 engines in all.

And 190 bogie trucks with bodies 31′ long and sides 18″ high.

Flat-topped trucks without any sides have been found to be quite good enough for rail carrying.

The erection of the wagons is a very simple matter with the aid of a steam crane or even a derrick with hand tackle. There should be

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no difficulty in erecting from 5 to 10 wagons a day, once the gang have got into working order, if all the parts are available.

For the erection of a locomotive, a fixed four-legged gantry made of 12′ × 12′ timbers was erected over a siding and fitted with a 15-ton differential tackle.

Nearly all the engines were erected single handed by Corpl. Gatford, R.E. with very inefficient natives to help him.

The second Emir engine erected by him in 1908, was started on November 26th, the frame wheeled on November 28th, boiler mounted on December 4th, tender mounted on December 7th, and the engine completed for trial run by December 16th, or a period of three weeks. An enormous amount of delay and trouble, and possibly the loss from traffic of one or more locomotives for several weeks, was obviated by the simple expedient of marking all the cases and packages belonging to each locomotive with a distinctive broad band of colour, thus enabling the complete locomotives to be sorted out without any delay from the hundreds of similar cases discharged during the shipping season. Certain cases of locomotive parts had to be opened on the beach in 1908 on account of their weight, and the parts carried up separately. A European and a gang of natives were told off to take special charge of such cases and to see them repacked in the store. It is important that the spare parts for locomotives should be placed in a separate store, preferably in charge of the Locomotive Superintendent. The cases containing the locomotives were arranged by engines on rail beds close to the erecting gantry. The boilers, frames and tender bodies were allowed to remain under load on trucks till erected.

To facilitate running repairs a wheel pit should be constructed without delay, and should be of sufficient width to enable a pair of wheels to be drawn out sideways from under the locomotive and lifted clear without the necessity of moving the engine.

A great deal of trouble was experienced from hot boxes in the case of the wagons, due firstly to a slight defect in their design and also to the necessity for putting them into regular work before the brasses had time to bed down properly. The difficulty was at length got over by temporarily reducing the loads and by increasing the wagon inspection staff.

The engine driver always has a hard time of it on construction, and this more particularly applies to the tropics where continual overtime cannot be worked with impunity. In the early days also there were no firemen, and the driver had to do a great deal of the firing himself until he had trained a raw native. The drivers of all engines are Europeans, except in the case of shunting engines, which are driven by Coast natives.

During construction we have had to content ourselves with the most elementary running statistics. To obtain these and also to train the

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drivers in readiness for open line working, the same form of Enginemen's Train Bill as is in use on the Lagos Government Railway has been employed from the commencement.

An expert boilersmith used to locomotive running work has been engaged. I am glad to say that he has not yet reported any ill effects from the use of wood fuel.

TRAFFIC.

The organization of a traffic staff has presented the greatest difficulties owing to the impossibility of obtaining trained natives from other West Coast railways. The first station masters had to be specially trained and the simplest possible working adopted. In February, 1909, an assistant traffic manager was sent out to take charge of the details of organization, and has worked wonders.

On the first section, the grades being very flat, one train a day in each direction met all requirements, and the traffic was worked on the system of a definite time table which could only be modified by the Assistant Traffic Manager at Baro. At the end of the season, Tyers' Electric Tablet instruments were installed up to Minna and have been in use ever since. A great many interruptions were caused by bush fires, but it is hoped this will be avoided in future by maintaining a fire belt.

In the season 1909–10 the section north of Minna had to bear from two to four trains daily in each direction, and pending the installation of electrical staff instruments, the train staff and ticket system was introduced and required a great deal of careful arrangement to ensure the staff always being at the right end. To avoid serious delays the traffic officer in charge of this section was authorized to arrange irregular working, on his authority alone. Construction regulations of which a copy is here for inspection were drawn up in 1908, and include rules for train working and for the guidance of the whole construction staff.

In order to lose no time in accustoming the natives to the advantages of the railway, a simple system was introduced whereby natives can travel at very cheap rates on the top of the construction material, and take with them their country produce to the neighbouring markets. A form of ticket was designed to meet our requirements and is still in use. Few railways can record that they started carrying public traffic before the railhead reached the first station 14 miles from the base. So early as the month of February, 1909, nearly 4,000 passengers travelled on the line.

By December, 1909, the station staff up to Minna was sufficiently trained to justify the adoption of a system of station accounts approximating that on open lines.

It was desired to allocate the cost of rail transport to the various

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subheads on construction, but it is questionable whether for a pioneer line the value of the information is worth the amount of trouble involved in obtaining it.

On the whole we have been fortunate in being singularly free from accidents of which there have been few fatal ones. This is the more astonishing in view of the fact that the native who passes his village while on the train often thinks it is the correct procedure to jump off. I have seen this happen several times and only once was the native sufficiently stunned to be caught.

An ice and mineral water plant at Baro, adds to the comfort and health of those of the staff who have to live at or near that mosquito-ridden place.

Royal Engineers Detachment.

The first detachment of ten N.C.O.'s under Capt. Mance, arrived at Baro early in August, 1908, in time for the shipping. The second detachment under Lieuts. Hammond and Maxwell arrived early in November in time for the plate-laying. The third detachment, completing the 30 men, arrived in January, 1909. All the men of the detachment were granted the local rank of sergeant.

After the first few months, when some of the men not constitutionally suited for the country were invalided home, the health of the detachment was on the whole well above the average, though I am sorry to say we lost one man, Sapper Guy, from blackwater fever, complicated by heart trouble. The climate of Northern Nigeria is far healthier than that of any of the other West Coast colonies, and the right type of man should have every prospect of keeping fit if he observes certain simple precautions, namely taking his quinine regularly; never sleeping except under a mosquito net, which should be kept in perfect order; wearing mosquito boots instead of shoes in the morning and evening; always wearing a helmet between 8 a.m. and 5 p.m.; wearing a spine pad especially during the hot weather, and not disdaining the use of an umbrella; keeping an extra blanket at the foot of his bed under the mosquito net to draw up the cool of the morning, living temperately and in no case touching intoxicants before sundown, and taking as much exercise as possible. In order to ensure a cheap supply of good provisions some 250 "chop boxes" were taken out from England, and issued to the detachment at cost price as required during their first tour. On subsequent tours the men had the experience and the means to take out provisions for themselves.

The work has been an excellent experience for both officers and men and most valuable training for railway work in war. As regards plate-layers, experience has shown that we can give them sufficient training in the Corps. Young sappers, who had been in training at Longmoor for only one year, were sent out in charge of

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the construction train, or placed in charge of a maintenance section within six months in Nigeria. To obtain suitable engine drivers, there is no doubt that we should enlist firemen with a few years' experience, as the Corps training and practice is not enough in view of the responsible duties of engine drivers. Nearly all the R.E. drivers in the detachment have had previous civil experience as firemen, and their subsequent R.E. mechanical and general training has given them an all-round knowledge which has led to their doing conspicuously good work in positions of considerable responsibility.

The following are a few figures showing the progress of the work :—

PLATE-LAYING PROGRESS—BARO-KANO RAILWAY.

1907–8	$6\frac{1}{2}$	miles main line only.	
1908–9 :—			
October 22nd–31st	$2\frac{1}{2}$	,,	,,
November	$5\frac{3}{4}$	,,	,,
December	9	,,	,,
January	$17\frac{1}{2}$	,,	,,
February	17	,,	,,
March	14	,,	,,
April	$11\frac{3}{4}$	,,	,,
May and June	15	,,	,,
	99	,,	,,

1909–10 :—

Month.	B.K.R. Main Line Mileage.	Additional Track Laid.	Link Main Line.	Link Sidings.	Cutting Out Deviations.
October ...	4	—	—	—	—
November ...	$15\frac{3}{5}$	$\frac{3}{5}$	$\frac{2}{5}$		—
December ...	$16\frac{2}{5}$	$1\frac{3}{5}$	—		—
January ...	$17\frac{1}{5}$	$\frac{4}{5}$	—		—
February ...	$16\frac{2}{5}$	$1\frac{3}{5}$	8		—
March ...	22	$1\frac{3}{5}$	9	1	$4\frac{2}{5}$
April ...	$18\frac{3}{5}$	$\frac{2}{5}$	$3\frac{2}{5}$		$1\frac{1}{5}$
May ...	2	—	$16\frac{3}{5}$		?
June ...	—	—	$\frac{3}{5}$	$\frac{1}{5}$	?
		$6\frac{3}{5}$			
		$\frac{4}{5}$*			
	$112\frac{4}{5}$	$7\frac{2}{5}$		$1\frac{1}{5}$	$5\frac{3}{5}$

Total main line B.K.R. $211\frac{4}{5}$. Zungeru Link 38 miles. Total 250 miles.

* Third leg of triangle and extra sidings at Minna.

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THE "PERFECT" LOOPHOLE.

By Capt. P. S. Greig, R.E.

In an article on loopholes (in the January number of *The R.E. Journal*, 1907) by Capt. Mance, D.S.O., R.E., appeared the following paragraph and sketch :—

"The theoretically perfect loophole, which, however, for various practical reasons is hardly within the range of practical utility even to the keenest Sapper, would be a combination of a pivoted steel plate *a* and a fixed plate *b*.

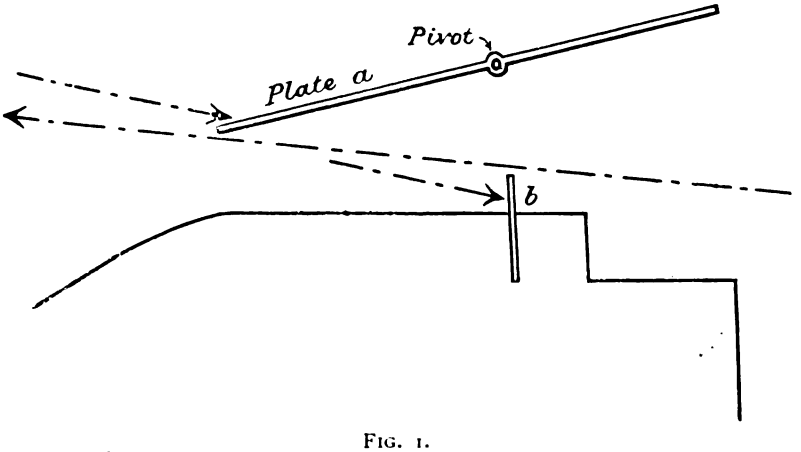

Fig. 1.

"The plate *a* must be canted just enough for the bullet to leave at the required angle of elevation for the enemy's firing line. The angle of descent at any range being greater than the elevation, the defenders would be immune!"

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Such a challenge could hardly be allowed to go by unheeded, and without claiming to be on the topmost pinnacle mentioned by the author, the casuals of the 54th Company, R.E., in their recent field-works course endeavoured to test the practical difficulties of the problem. The "Heads I win, tails you lose" loophole is of too alluring a nature to be abandoned to the barren regions of theory without an effort. The accompanying photographs A and B show

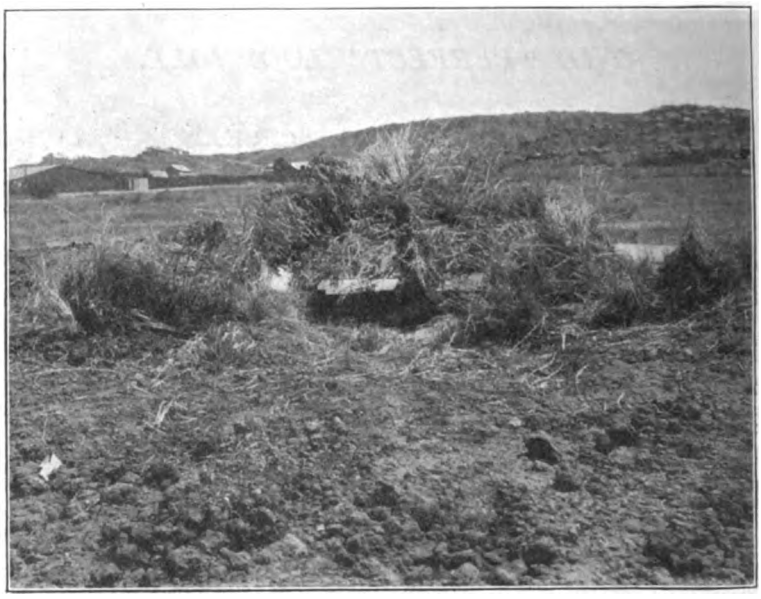

Photo A.

front and rear views of such an effort, the loophole being constructed out of iron plates picked at random from store, a short length of water piping (to serve as pivot), two short pieces of timber, some wire (to adjust elevation of plate) and a nail (to be seen on right of helmet in *Photo* B).

The loophole is not very conspicuous from the front; in fact, considering that the photograph (A) was taken at a distance of only 6 yards it will not be found easy to detect the man in the trench behind, and the muzzle of a rifle looking direct at the observer. Further, seeing that the defenders are presumably immune the conspicuity of the head cover is not a matter of much moment!

The practical difficulty seems really confined to the finding of the iron plates which of course do not grow on the veldt or on the open battlefield. They should however be available for any work of a

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semi-permanent nature. For the rest, some pieces of water piping iron standards, or short lengths of wood to form the pivot, and a little wire are all the stores required.

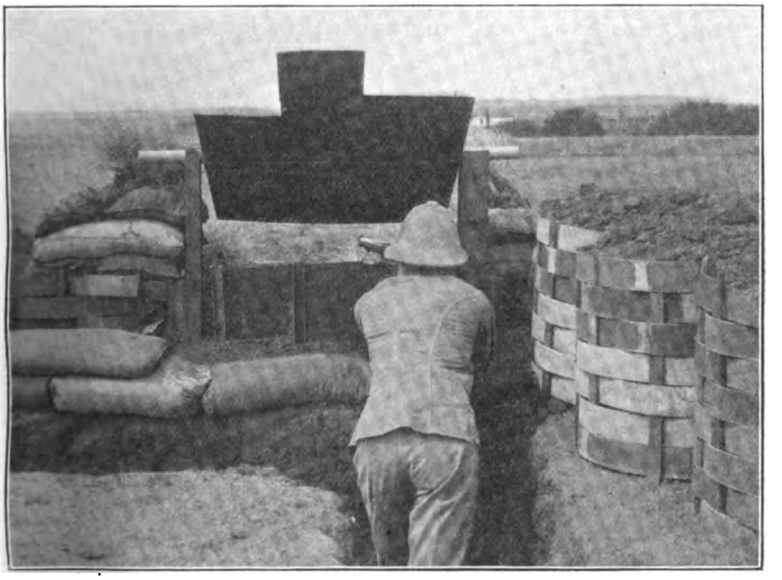

Photo B.

Capt. Mance mentions that at the Siege of Mafeking the defenders employed a very serviceable type of loophole—an iron plate about $3' \times 1'\ 3'' \times \frac{1}{2}''$ thick bent at right angles with a small rectangular hole at the angle (*Fig. 2*).

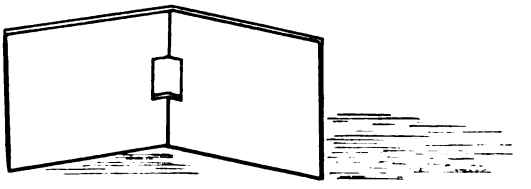

FIG. 2.

One of these plates was struck by 26 bullets! With this type of loophole, however, the defender, if of a mathematical turn of mind, will be wondering all the time what the chances are of a bullet finding its way through the rectangular hole and thence to its billet. The nervous wear and tear of the survivor of the

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26 hits must have been prodigious. No such problem harasses our defender of the "perfect" loophole. The pattering of bullets on the plate will be as music to his soul for he is buoyed by the certain knowledge that in the long run it is a case of "Heads I win, tails you lose," and as he draws his bead for the last time upon the foe he softly murmurs "He laughs best who laughs *last*."

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A REPORT ON TORRES VEDRAS.

THE original manuscripts of the following interesting documents have been kindly presented to the R.E. Institute, for the R.E. Museum, by Sir Lawrence T. Jones, Bart.

The manuscripts are rough drafts of a letter and report sent by Sir J. T. Jones (grandfather of the donor) to Sir Richard Fletcher, C.R.E. in the Peninsula. They refer to the Alhandra position of the lines of Torres Vedras, and were written some two months before the British Army retreated behind the lines. Unfortunately no copy seems to have been made of the hand-sketch which accompanied the report and which is referred to in the letter.

LISBON, *29th August*, 1810.

SIR,

In consequence of your wishes, I have now the honour to enter into some detail respecting the position at Alhandra and of the means to prevent its being turned. I enclose a paper of memoranda which I drew up yesterday when on the spot, it must be read as relating to the state of the work on Saturday next and will I hope prove a satisfactory account of that strong position.

The ground on the opposite side of the valley on the left is a range of strong hills of a much superior elevation to any other ground near them and connected by a regular descent with the Hills in rear of the position—at a point about a mile retired from the front of the Alhandra Position, this ridge terminates to its left with a bluff point which overlooks all the Country to the Ajuda Works at the distance of perhaps in a straight line between them of less than three miles—at this spot it appears to me that a post might be formed for fifteen hundred men extending completely across the ridge one flank of which shall appui on the bluff point and consequently overlook the Country in that direction, the other flank appuiing on the valley which forms the left of the Alhandra position and its fire co-operating with the Alhandra Redoubt preventing the passage of an enemy through the valley. This post would so thoroughly occupy these hills as to prevent the march of Infantry to the rear otherwise than by the space of two or three miles between it and the Aguda works and it would leave the whole Army at liberty to act in that difficult Country whilst the Enemy would have the Garrisons of Pobral and

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Alhandra in their rear. I should conceive it too hazardous an enterprise for them to attempt—if that is allowed it follows that it would secure Alhandra from being turned by an Enemy with or without Artillery.

I have one feeling of doubt on my mind which it is my duty to state and that is the possibility of an enemy forcing the valley between the two works. I will here state what has been done to secure it, that, if not judged sufficient orders may be sent for further obstacles being created—at its entrance eight 12 Prs. in inattackable situations can shower down grape shot upon the Enemy and during a passage of half a mile they will always be under the fire of at least six pieces of that nature of ordnance and for some part of the way under ten,—the work now proposed will give an additional cross fire and will prevent an entry into the valley by a collateral branch which exists about midway and which is a most serious disadvantage.

It is however to be recollected that the fire of the Artillery is from a very great height, and that much cover is created in the valley by hollow ways and steep rising grounds, and that in the night time the fire will be often uncertain; when an attack is expected it will be proper to cut down the Trees, and place them as an obstacle across the valley and also to level the houses, walls, etc.

The works I propose to construct are three Redoubts for four hundred men each mutually flanking each other with a smaller work in advance to look down the valley in front which the three forming the Position cannot do,—it is proposed to make them to resist Cannon and they being nearly a mile retired from the front of the Alhandra position I do not think any Enemy dare to bring up Artillery for their reduction without having first forced Alhandra, for as the rear of that post will be open to the Army and hid from him, he can never tell whether there are four or fourteen hundred men it.

1st. I have sent a hasty sketch from memory of the ground but which I trust will be sufficient to point out the situation of the proposed works.

2nd. The soil is very unfavourable for this construction of works it will therefore require nearly two months to complete them from the day of their commencement.

MEMORANDA RELATING TO THE POSITION OF ALHANDRA.

Sent to Lieut.-Colonel Fletcher, Commdg. Royal Engineers.

LISBON, *August 29th*, 1810.

The position of Alhandra as now taken up is formed of an isolated range of heights, its right bounded by the Tagus, its front left and part of the rear by a deep and difficult valley. It may be viewed under the three divisions of its front left flank, and rear.

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The front naturally subdivides into two parts :—1st an extent of upwards of 2,000 yards on the left, which has been so cut and blasted as to give it a continued scarp everywhere exceeding 10 feet in height, flanked in its whole length by musketry and Cannon—and the approach to the scarp laying under a fire of grape shot. Large general flanks have been established for that purpose, and *Redoubts have been erected on the summit, for the security of the Guns and Troops should any part of the position be forced.

The second Division of the front is an extent likewise of about seven hundred yards, more than half of it the low flat ground bounding the Tagus, the remainder is the slope of a hill of easy ascent gradually rising from the low ground till it meets the artificial scarp.

This whole length has been intrenched by a continued flanked line of a strong profile, across the low ground an advanced ditch has been added, flanked from the line ascending the hill, and which has likewise been made to answer as a powerful flank to the low ground generally, at the left extremity of this line, and at the point where the nearly inaccessible part of the front ceases a Redoubt has been thrown up.

The left of the Position may be considered as having a front of half a mile, the ground is very high and steep, but not inaccessible. Two Redoubts have been established there, the one on the most commanding point of the whole Position for 400 men, and eight 12 Prs., the other on the left for 350 men, and six 12 Prs.

A species of Redoubt or Flèche has been thrown up where the nearly inaccessible part of the front finishes on the left, for which perhaps 150 men should be apportioned, as in case of necessity they can support the front or flank as either may be pressed.

Scarping and other impediments of that nature have also been attempted with success so that the left flank may be considered only less strong than the front.

The rear of the position is above $2\frac{1}{2}$ miles in extent, it is very open and of easy ascent and one part of it is commanded by a range of Hills, the occupation of which by an Enemy would turn all our defences, and most probably cut off the retreat of the Troops.

There are but three ways by which an Enemy can get in the rear or obtain possession of the above-mentioned ridge of Hills.

1st. By forcing his way through the valley on the left.

2nd. By marching a Column along the opposite heights of Calhandrin, parallel to the left flank.

3rd. By making a detour to his right of several miles.

* Leaving the rear out of the calculation, Alhandra with a proportion of Artillerymen (say 200) for the forty Pieces of Cannon mounted upon it may be considered as almost an inattackable position for Five Thousand Men, and might in case of necessity be safely left to the care of Four Thousand Men.

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To guard against the first a height detached in advance of the position on the left has been occupied by a work for 250 men and five 12 Prs., and which from its situation and construction is so strong that it ought never to be forced, the fire from this work, and from the redoubts, with an abattis may perhaps be deemed sufficient to prevent an enemy from passing along the valley.

The second passage might be impeded by the construction of a post for fifteen hundred men upon the Hills parallel to the left flank, at present to carry Artillery by that route it would be previously requisite for the Enemy to force a redoubt above Francoso.

The third method can only be properly opposed by the Manœuvres of the General Commanding the Army, but its bad effects might probably be counteracted by the erection of a strong work on the rear range of Hills where it would be the object of an Enemy to establish himself.

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EARLY ROMANO-BRITISH PEACE OR WAR CONSTITUTIONS.

By COLONEL O. E. RUCK, LATE R.E.

IN the *R.E. Journal*, April, 1910, Colonel Hickson, D.S.O., continues the exposition of the constitutional methods initiated by Servius Tullius, and, by the contribution of additional facts, still further strengthens the closeness of the similarity of the Servian politico-military organization to that of Henry II. in this country.

In tracing the evolution of the Comitia Centuriata of Servius from the Curiata of Romulus, as studied and interpreted by Niebuhr and Mommsen, Colonel Hickson is helpful to the student of military history by shedding many an illuminating sidelight on matters of detail on controversial points, some of which the original Roman historians do not themselves, in all cases, appear to absolutely agree upon.

For instance the original Tribal System, tending as it did to create local and intertribal contentious bickering, necessitated a complete reorganization by the strong hand of a strong man. Servius Tullius with far-reaching prevision stepped in, introducing a new system distributing the citizens into tribes, not as before according to racial or family extraction, but dependent upon their local situation.

The first original three tribes consisted of No. 1, named after Romulus and included the Roman citizens of the Palatine; No. 2 which consisted of the Capitolines and Sabines; No. 3, the Tuscans and all foreigners except the Sabines. Tarquinius Priscus soon doubled the number of tribes but in a short time, No. 3 tribe greatly exceeded the rest in number and caused an inconvenient distribution which led to the Servian reconstitution.

Servius divided the city tribes (Tribus Urbanæ) into four, viz., Palatina, Collina, Suburana, and Esquilina as per Niebuhr, and at the same time divided the Roman Territory into 15 (some say 16, and some 17) called (Tribus Rusticæ) or country territorial tribes.

In the year A.U.C. 258, B.C. 495, the number of tribes was made 21;[1] afterwards the number of tribes was increased by the addition of new citizens at various times up to 35 in number,[2] (which number continued to the end of the Republic).[3] After the admission of the Italian states to the freedom of the city, 8 or 10 tribes are said to have been

[1] Livy, II., 21. [2] Livy, XXIII., 13. [3] Li . 1., 43.

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temporarily added, but in a short time all the Italians were distributed amongst the 35 old tribes.

In the very early days of Rome, the original three tribes of Romulus were divided into 10 curiæ, the whole territory of Rome—then very small—being also divided into three unequal parts, the largest of the three being again divided into 30 portions to answer to the 30 curiæ.[1]

The people were divided into two ranks (ordines) Patricians and Plebeians, the equites being added by Servius Tullius some 200 years later. From each tribe Romulus chose 1,000 foot soldiers and 100 horse,[2] hence these 3,000 infantry and 300 cavalry formed the original legion for which reason Niebuhr's mention of 30 men to the century of the original legion (for explanation of which Colonel Hickson desired in his footnotes), is correct, at 100 centuries to a legion. But the number of men in a legion was different at different times.[3] In the times of Polybius it was 4,200, at one time there were 93 centuries in a legion,[4] and if there had always been 100 men in each century as its name implies, the legion would have consisted of 6,000 men. But this was not the case.

With regard to the same quotation from Niebuhr's "Von den Comitien, etc.," for which explanation is required by Colonel Hickson—"Levies were made according to the tribes, of which there were 35 (see Dionysius, IV., 14)"—it would appear that differences of opinion between Dionysius and Livy existed as to numbers, writing as they did some 300 to 500 years after the events recorded. For in the year of the city 258 the number of tribes was made by Livy to be 21.[5] Dionysius (IV., 14) states that Servius instituted 30 tribes, but at the trial of Coriolanus, A.U.C. 263, or only five years later, he mentions 21 the same number given by Livy as having voted.[6]

Be that as it may, for a considerable time after the constitution of Servius Tullius, a tribe was nothing else but the inhabitants of a certain region or quarter in the city or country; but afterwards the tribes came to be reckoned parts—not of the city or country—but of the State (non urbis sed civitatis). Whereupon everyone leaving the city tribes wished to be ranked in the rolls of the rustic tribes; such was the fondness of the ancient Roman for a country life aided in some degree by the pressure due to the power of the Censors who could initiate new tribes, and distribute the citizens, both old and new, into whatever tribes they pleased, irrespective of place of habitation or birth.

In the year A.U.C. 449, Q. Fabius separated the meaner sort of people from all the tribes amongst which they had hitherto been distributed by Appius Claudius, thereby relegating them to the four city

[1] Dionys., II., 7. [2] Plutarch in Romulo. [3] Livy, VII., 25; VIII., 8; XXVI., 28; XXIX., 24; XLII., 31; XLIII., 12; Cæs., B. G., III., 100. [4] Gell., XVI., 4. [5] Livy, II., 21. [6] Dionys., VIII., 64.

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tribes;[1] amongst these were many of the Proletarii (under 1,500 asses valuation apiece) and the Capite Censi men, Agrarians, and those who were rated at no assets at all!

From this time, and perhaps before, the four city tribes began to be esteemed less honourable than the 31 rustic tribes; and some of the latter appear to have been considered more honourable than others.[2] Hence when the Censors deemed it right and proper to degrade a citizen, they removed him from a more honourable to a less honourable tribe (tribu movebant); and whosoever convicted anyone else of bribery or corruption, upon trial thereof, obtained by law if he chose as a reward, a transfer or exchange into the tribe of the person so convicted or condemned.[3]

These rustic tribes took their names from some territorial place such as Tribus Falerino, Levonia, Cluvia; sometimes from some noble family, *e.g.* Tribus Claudia, Fabia, Julia, Veturia, Horatia; occasionally the name of the tribe is added as a surname, *e.g.* M. F. Terentina, Sex. F. Quirina.[4]

In determining what classes of men came out under the regular annual conscription it is necessary to know the exact period of the 500 years' more or less continuous warfare alluded to, and if for a small war, or whether a case of (in tumulto), *i.e.* a state of panic prevailing; a not unheard-of contingency, even in the case of the great Imperial Roman organization.

Colonel Hickson quoting from Niebuhr with reference to the comparatively insignificant number of engineers and artificers included by Livy in the Classici or First Class of the Servian Comitia, suggests that these useful men may likely have been drawn from the trade guildsmen of ancient Rome.

It is difficult to avoid the thought that Niebuhr,—in stating that these artificers attached to the Classici could not have been plebeians, as no plebeian could engage in any occupation other than that of agriculture,—may have been alluding to a later period of Roman society.

It has been commonly supposed that all the Roman citizens, with the exception of the Patricians and Equites were classified in the times of the Kings and early Republic as Plebs[5] or Populus. But the word Plebs has not infrequently been applied to describe the meanest or lowest class of the then so-called common people, *e.g.*, ad populum, plebemque referre.

Thus Horace speaks of 'unus e plebe, *i.e.* a plebeian not an eques.'[6] Those of the plebeians who lived on and cultivated land in the country were 'Plebs Rustica.'[7] Those who lived in the city 'Plebs Urbana.'[8]

[1] Livy, IX., 46. [2] Cic. pro Balbo, 25; Pliny, XVII., 3. [3] Cic. *ibid.* [4] Cic., Quint., 6. [5] Cic., Fam., VIII., 8; Gell., X., 10. [6] Horat., Ep. I., 1, 59. [7] Livy, XXXV., 1. [8] Cic., Off., I., 42; Sall., Cat., 27.

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Of these two classifications, that of the Plebs Rustica was deemed the most honourable.[1]

Many of the Urbana possessed of no trade and being very poor had to be supported by private largesses,[2] whilst in the latter times of the Republic these urban unemployables were, at the public expense, granted a subsistence allowance of 5 bushels of corn per man per month.[3] Cicero alludes to them as 'mercenarii'[4] 'Fex et sordes urbis,' 'urbana et perdita plebs' and often contrasts the plebs or multitudo with the nobility (principes delecti, benesti and locupletes).

But from whatsoever class the Engineer artificers attached to the 1st Class or Classici by Livy came, whether they were plebs rustica, plebs urbana or not of the plebeian order at all, but freedmen or Peregrini[5] (foreigners) as per Niebuhr's suggestion, no authentic records can be traced, so far as can be ascertained to effectually establish their identity. But knowing as we do that foreigners in the times of Tullius were ineligible for the army and that freedmen were just beginning to feel their feet as hired gladiators,[6] and that by the laws during the Tribuneship of C. Papius Celsus, A.U. 688, all foreigners were ordered to quit as undesirable aliens,[7] we cannot but think that the engineers attached to the Classici came from a then more honourable class of the community, in the absence of preponderating evidence to the contrary.

[1] Cic., Rull., II., 31; Pliny, 18, 3. [2] Sall., Cat., 37. [3] Sall., Frag. edit. Cortii, p. 974. [4] Cic., Sext., 17, 27, 48, 68. [5] Cic., Off., I., 12. [6] Horat., Sat., II., 7, 5. [7] Cic., Off., III., 11; Brut., 8.

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RECENT INVESTIGATIONS INTO THE THEORY OF DEW-PONDS.

By COLONEL W. PITT (LATE R.E.).

DURING the past two or three years a considerable amount of attention has been paid to the subject of dew-ponds by some of the leading scientific bodies, and important investigations have been carried out. The result of these enquiries appears to be that the time-honoured tradition regarding these ponds must be regarded more or less as a myth. It is possible that the reports of the proceedings may have escaped the notice of some who are interested in the subject, especially as they are published in the journals of different societies; it is therefore proposed in the following notes to give a brief description of what has been done and the conclusions arrived at.

Anyone who is acquainted with the downs in the southern counties of England knows that there are numerous ponds scattered about them, especially at the higher levels, which are used for watering sheep in an otherwise waterless country. All officers who have taken part in manœuvres in these counties know that stringent orders against the use of these ponds by the troops are invariably issued. In the great majority of cases the ponds have no visible source of supply, though sometimes where they are situated near a road or track a channel is cut to lead surface drainage into them, yet they are seldom found to be dry. It is obvious of course that they get the benefit of any rain which falls on their surfaces, but it has been held from time immemorial that they are chiefly replenished by dew or condensation from fogs. For this reason they are known as "dew-ponds" in some parts of the country, or "mist-ponds" in others.

It is claimed by some archæologists that dew-ponds were in use in the Neolithic age, and that the hilltop camps of which there are so many on the chalk downs were dependent on them for their water supply.* It is not proposed to consider this question here.

Extraordinary beliefs have been prevalent, and statements made, as to the quantity of water which might be deposited on the surface of a pond in the form of dew. In his monumental work on ancient

* *Neolithic Dew-Ponds and Cattle-Ways*, Arthur John Hubbard, M.D., and George Hubbard, F.S.A., etc.

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earthworks* Mr. Hadrian Allcroft has a chapter on dew-ponds in which he says that "it has been found by actual experiment that a dew-pond may rise as much as 2" in a single foggy night of January, and in five nights rise fully 8". In the early summer the same pond collected 3½" of water upon five nights of heavy dew." No particulars are given as to the pond or details of the experiment. It appears that we are asked to believe that the deposit from dew alone may be equivalent to a rainfall of 2" in about 14 hours which would necessitate a heavy downpour, such as is rarely experienced in England, during the whole of that period! The thing is incredible. There may have been trees overhanging this particular pond and dripping on to its surface but even so the statement is difficult to believe. Although the facts as put forward by Mr. Hadrian Allcroft may have been regarded as an exaggeration, or describing an improperly carried out experiment, or relating to a peculiar case, the popular belief was in the replenishment of the ponds, in the main, by dew. There were however those who doubted.

The matter was taken up by the Royal Society of Arts and on March 3rd, 1909, at a meeting of that society, a paper was read by Mr. George Hubbard which was published in its journal.† Mr. Hubbard described the theory of the deposition of dew and the principle on which dew-ponds are constructed, the most important detail being the laying of a bed of straw under the clay puddle. The object of this was explained to be the interposition of a non-conductor between the earth and the clay, and so prevent the radiation of heat from the former during the night and encourage the deposition of dew on the cold clay sides of the pond as well as on the surface of what water there might already be in it. Reference was made to the way in which ice is, or was, obtained in India from shallow earthenware pans resting on a bed of straw. Mr. Hubbard stated that dew-ponds on hills are more successful than those in valleys and he gave a curious reason for this. His theory is that air carrying aqueous vapour rises and in higher altitudes expands, consequently the temperature falls and condensation ensues; also that hilltops radiate easily and act as condensers. It may be remarked that this explanation hardly seems convincing.

Mr. Hubbard went on to say that dew-ponds are only successful when constructed on a chalk bottom, because "chalk is a sterile soil, and it is owing to the absence of worms that the layer of straw can remain dry." This also seems to be rather what a Hampshire shepherd would describe as "dubersome." I know that when I had a garden on chalk with only 4" or 5" of soil there used to be plenty of worm casts on my lawn. It seems probable that ponds are more numerous on chalk downs than elsewhere because there are no

* *Earthwork of England*, A. Hadrian Allcroft, p. 275.
† *Journal, Royal Society of Arts*, March 5th, 1909.

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springs or streams from which water for sheep and cattle can be obtained, also because, as will be shown later, the rainfall is heavier on the hills than in the valleys, and near the coast the hills get more mist and sea fog.

After describing some experiments in condensation on wooden trays standing on sheets of mica, the paper goes on to suggest the adoption of dew-ponds as a means of obtaining water in barren rainless lands such as the Desertas Islands near Madeira, and describes the effect of trees and vegetation in encouraging the deposition of dew.

Mr. Hubbard next refers to the covering of a portion of the rock at Gibraltar with corrugated iron on a wooden backing, on which he says "the warm moisture-laden wind becomes chilled and the dew is deposited, and if I am rightly informed Gibraltar has now a supply of pure water." It was however subsequently pointed out by another writer that this structure was erected with the object of collecting rain and not dew.

The paper concluded with some remarks on the use of various substances as non-conductors and condensing surfaces, and suggestions that by making use of the dew, the arid places of the earth such as the Transvaal, Australia, and parts of India might be made fertile.

An interesting discussion followed the reading of the paper in the course of which Mr. G. Blundell said that many dew-ponds in Wiltshire and Sussex were made with the straw on the top of the clay puddle to keep it from cracking, and with a layer of rubble on the clay. In his reply Mr. Hubbard reiterated his statement that in Sussex the exact opposite was the custom. He also said that the depressions often found in the South Downs were probably ancient dew-ponds. This I believe to be an error. In a paper contributed to the *R.E. Journal* on "Swallow Holes in Chalk"* I explained that these depressions are a natural formation, but even if this theory is incorrect they cannot all have been dew-ponds, there are too many of them, and they vary too much in size. On the chalk hills of Hampshire the fields are riddled with such depressions, you will find six or eight in a single field often close together; some are much too large and deep, others too small and shallow. Moreover there is absolutely no trace of the bank round which must have been formed by the earth thrown out if they had been excavated artificially.

Mr. Hubbard's paper attracted a good deal of attention and was followed by some correspondence in the *Journal of the Royal Society of Arts*, chiefly as regards details of construction. Then an article signed E.A.M. appeared in *Nature*.† The writer of this was no doubt Mr. E. A. Martin whose important investigations will be referred to later. He controverted the theory that the ponds derive their water supply from dew, and pointed out that evidence is wanting that the

* *R.E. Journal*, May, 1909.
† *Nature*, April 22nd, 1909.

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temperature of the water in the ponds falls below dew-point during the night: so long as the surface of the water remains warmer than the air, dew cannot be deposited on it. Mr. Arthur Beckett also wrote to *The Field** giving particulars of the method of construction of dew-ponds on the Glynde Estate near Lewes and saying that he had been forced to the conclusion that the ponds depend for their water chiefly upon rain, and in a much smaller degree on mists and hill fogs. These views were controverted by "East Sussex" but reiterated by Mr. Beckett.

E.A.M.'s article in *Nature* was replied to by Mr. Hubbard in the *Journal of the Royal Society of Arts*† in a note in which he admitted that probably dew, *per se*, forms a very inconsiderable factor in the supply of dew-ponds. He went on to quote the following important figures.‡ "On the summit of the South Downs the annual rainfall is from 35″ to 40″; the annual evaporation is certainly not more than 20″, and so from rain alone a pond should accumulate a depth of 15″ to 20″ a year, supposing the bottom to be watertight"—and of course that sheep are not watered at it. With reference to E.A.M.'s statement that evidence is lacking that dew-point is reached in the ponds Mr. Hubbard quotes as a proof Mr. Hadrian Allcroft's remarkable figures which have been mentioned earlier in this paper. The experiment described by Mr. Allcroft was, Mr. Hubbard says, carried out by Mr. C. J. Cornish.

Mr. J. B. Cohen wrote to *Nature*§ saying that he had always been sceptical about the dew-pond theory for the reason that "lakes and ponds lose their heat slowly, and that after radiation has set in at night they indicate a much higher temperature than the ground adjoining, or the air above." To this objection Mr. Hubbard replied‖ that "it is not the temperature of the bulk of the water that, in my opinion, regulates the deposition of dew, it is the temperature of the surface film of water which is alone involved, and this is not readable on the scale of an ordinary thermometer." He said that on this account the results obtained by Mr. Cohen and Mr. Martin appeared to him purely negative. With reference to the above it may be remarked that when the water in a pond is cooling at night we should expect it to do so from the top and that it actually does so was conclusively proved by Mr. Martin in his experiments which will be referred to later. Even if he were unable to take the temperature of the surface film, it is difficult to believe that this can be higher than that of the water immediately below, which at night rises regularly to the bottom.

* *The Field*, March 20th, 1909.
† *Journal, R.S.A.*, May 14th, 1909.
‡ *Symon's Meteorological Magazine*, April, 1909.
§ *Nature*, May 13th, 1909.
‖ *Journal, R.S.A.*, May 21st, 1909.

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We must now go back to 1908. In the summer of that year Mr. E. A. Martin with the aid of a Royal Society Government grant began a scientific examination of the subject of dew-ponds, on the Sussex Downs, and continued his observations the following summer. The results of his investigations will be found in two papers read before the Research Department of the Royal Geographical Society on April 22nd, 1909,* and April 21st, 1910,† but in both cases they were not published till some months later. These papers are of great interest and contain a mass of information including several pages of tables of temperatures. It will not be possible here to do more than refer briefly to some of the more important points and give the conclusions arrived at by Mr. Martin. Those who wish to pursue the subject further are referred to the pages of the *Geographical Journal.*

In his first paper Mr. Martin starts with the postulate that "certain high level ponds maintain their supply in the driest, hottest weather, long after those in the plains below have more or less completely dried up." He says that this has been attested by many observers, from Gilbert White onward. He observes that to be useful, ponds must receive dew in summer, in winter they are fed by rain. He constructed a dew-pond for the purpose of carrying out experiments and records that on the night of September 21st, 1909, the temperature on the grass fell from 52° to 30° whilst that of the surface of the water fell from 50° to 42·5°, dew-point being 45·5° on the grass, but it does not follow that the pond received any dew. The depth of water was only 4″. Mr. Martin remarks that evaporation may continue all night, and that he thinks a pond may receive dew while the water in it has not fallen below dew-point. In the subsequent discussion this suggestion was controverted and Mr. Martin has since modified his opinion. It does not seem possible that he can have been right. Further on in his paper Mr. Martin pointed out that if a pond is very shallow the whole body of water will be heated during the day to such an extent that it will continue evaporating throughout the day and night. He next described the various methods of construction and gave sections of ten different ponds all made in different ways and in various localities, including Yorkshire, Leicestershire, Essex, Dorset, Wilts, and Sussex. Of these ponds some had straw over clay, others straw under the clay, alternate layers of straw and clay, and two had no straw. Lime should be mixed with the clay to keep worms out.

The amount of the annual dewfall was then considered. Mr. Martin stated that this had been estimated at under 1·5″ on surfaces other than water. On a night when there was a heavy dew he collected it on a waterproof sheet and on measuring the quantity

* *Geographical Journal*, August, 1909.
† *Geographical Journal*, October, 1910.

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found it to be $\frac{1}{200}$". If this amount fell every night of the year the total would be 1·8104", but as it cannot be regarded as a fair average he estimates the annual fall at something over ¾". If the evaporation is deducted from this there will not be much left to feed the pond. Mr. Martin then considered the question of supply from fog or mist apart from ordinary dew. On the South Downs sea fogs cause great quantities of moisture to be deposited, especially at the higher levels, and for this reason hilltops are now chosen for pond construction. Trees overhanging ponds arrest the moisture and cause it to drip into them, reeds also growing in the water increase the deposition. As regards rainfall it has been observed that a gauge in a hollow measures more than one on the ground above. Mr. Martin kept a record of the fall measured in the hollow of his experimental pond and on the top of the bank. During 21 rainy days in August and September, 1908, the gauge in the hollow registered 3·51" and the other 2·57". In connection with this I have noticed that roots and cabbages growing in the depressions in chalk soil, previously alluded to, are finer than the rest of the crop. The water from a number of ponds was analyzed and found to contain an unusual quantity of chlorine, probably derived from condensation of sea fogs.

A discussion followed the reading of the paper.

Dr. Mill attributed the lower registration of rainfall on the edge of a pond to the setting up of eddies of wind, from which the gauge at the bottom would be sheltered. Mr. George Hubbard said he did not believe it is possible for a pond to receive condensation if the temperature of the water has not fallen to dew-point. Mr. Sidney Skinner stated that he had marked the level of the water in a pond in St. Boniface Down, Ventnor, and after two days of mist he found less water than before.

Mr. Carle Salter pointed out that whilst the collecting area of a pond as regards rainfall is always greater than the area of the surface of the water, the evaporating area is confined to the latter.

Now with reference to the experiments and investigations carried out by Mr. Martin it may be noted that he gives in his paper no periodical measurements of depths of water in any dew-ponds. When the evaporation and deposition nearly balance one another and the change of level is consequently slight, it may not be easy to ascertain the amount of it, there would however be no difficulty in measuring a rise of 2", such as Mr. Allcroft claims to have been recorded, or one very much smaller.

Mr. Martin's second paper contains the record of his much more complete observations made in 1909. He began by repairing the experimental pond he had constructed during the previous year. This had filled up during the winter but developed leaks after frosts. In July he excavated the pond to a greater depth. By the 20th

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there was enough water in it—presumably derived from rain—for him to commence his observations. There was heavy dew on the night of July 19th which made no appreciable alteration in the depth of water, and similarly on subsequent dewy nights the depth was always unaffected. On July 27th and 28th there was a heavy fall of rain measuring 1·21″ in 24 hours. A gauge in the pond registered 1·41″, but at Ditchling at the foot of the hill only 0·88″ fell. This brought the depth of water in the centre of the pond to 4½″. There was no rain from July 31st to August 15th on which date the water had nearly all gone. On August 11th there was a thick fog. On August 12th there was an inch of water remaining in the pond. All that the fog on the 11th did was to arrest evaporation.

Between August 4th and September 8th, at ten different points Mr. Martin took a series of temperatures at intervals during nearly every night, usually two or three before, and at midnight, and again at 7 or 8 a.m. The results are given in his paper in tables which it is not necessary to reproduce here. The important temperatures are those of the air immediately over the water, and of the water close to the surface. The bottom water temperature was taken, wet and dry bulbs in air, and dew-point recorded. The net result is that out of 101 records of the temperature of surface air and water they were equal on one occasion, on 16 occasions the water was lower than the air, and higher on 84. The lower water temperatures occurred in the early morning with two exceptions; once the water is recorded as 5° below the air at midnight, and again 0·5° lower. The first of these lower temperatures is probably incorrectly printed in the tables, it is shown as 63° at 10 p.m. and 52° at midnight the respective air temperatures being 59° and 57°. Probably 62° should be read for 52°. At night the temperature at the bottom was always higher than at the surface.

On August 14th and 15th, Mr. Martin recorded temperatures at a dew-pond at Upper Standean every hour for 24 hours, and states that "during the hours of possible dewfall the temperature of the surface air was, with but one exception (12.30 a.m.) always lower than that of the surface water, and on no occasion did that of the water approach dew-point."

Mr. Martin tried to collect dew in trays floating on the surface of his experimental pond. On the evening of August 26th he placed a measured quantity of water in a shallow glass dish. The night was dewy but the quantity of water next morning was the same as at first. On the night of September 7th a quantity of water was measured into a tea tray. There was heavy dew and thick fog and next morning the water was found to have increased its volume by three hundredths. This experiment was repeated in the daytime to ascertain the evaporation. On September 9th, a sunny day, two measured quantities of water were similarly exposed from 9 a.m. to

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6 p.m.; of these one lost ten and the other twelve hundredths of its volume.

Mr. Martin described some experiments carried out at Croydon by Mr. Baldwin Latham as to evaporation and condensation from which the annual average evaporation was found to be 18·14", and condensation 0·36", giving a net loss of 17·78". This amount deducted from a rainfall of 35" leaves 17·22" available for filling a dew-pond, or 34·44" if the area is multiplied by two to allow for the collection of rain on the banks. This should suffice to keep a pond full and allow for sheep drinking, but unfortunately the statement is misleading because the evaporation occurs mostly in summer whilst the greater part of the rain falls in winter. Yet ponds free from leakage seldom do dry up entirely and Mr. Martin thinks that mist or fog must come to the rescue.

A suggestion was made that the electrical condition of the atmosphere may have something to do with the deposit of aqueous vapour.

The conclusion finally arrived at by Mr. Martin after two years' investigations, and very much against his will is that dew very rarely forms on the surface of ponds or on their puddled margins, but that rain is the all-important replenisher of the so-called dew-ponds. The mystery of the dew-pond is no longer a mystery.

Those who took part in the discussion following the reading of the paper considered the result of the investigation to be conclusive, no one had a word to say in defence of the time-honoured tradition. Mr. S. Skinner said that Down labourers always told him that the ponds were filled by rain. He suggested that endeavours should be made to measure the deposits of dew and mist separately. Dr. Strahan thought there was room for further precise observations on the fluctuations in the water level.

It is a dangerous thing to abandon an ancient tradition until it has been thoroughly investigated, especially one so widely held as that relating to dew-ponds. The results of the scientific observations so ably and thoroughly carried out by Mr. Hubbard, Mr. Martin and others, however, leave us no option but to consign this belief, little as we may like doing so, to the limbo of popular delusions.

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TRANSCRIPTS.

NOTES ON THE THEORY AND PRACTICE OF FIELD FORTIFICATION.—MODIFICATIONS DRAWN FROM THE EXPERIENCE OF THE RUSSO-JAPANESE WAR.

By F. GOLENKIN, Military Engineer, Lecturer on Fortification in the Nicholas Engineer Academy (St. Petersburg, 1907).

THIS pamphlet contains a series of lectures on the modifications in field fortification which were suggested

(i.). By the experience of those who took part in the Russo-Japanese War.

(ii.). By articles published recently in Russian and foreign periodicals. and

(iii.). By the proceedings of a special committee, which was assembled under the orders of the Inspector-General of Engineers.

The following is a summarized translation of a few points in the book:—

DEVELOPMENTS OF FIREARMS, ETC.

Recent changes in weapons and equipment must materially affect the question of field defences. Among modern developments in *weapons* there may be mentioned:—

(*a*). The 6·5-m.m. and 7·6-m.m. improved quick-firing rifles, and their increased range and penetration due to the introduction of the sharp-nosed bullet.

(*b*). Machine guns of the same and of larger calibres.

(*c*). Q.F. artillery: light (guns) of calibres up to 8 cm., and heavier (howitzers) up to 10·5 c.m. and 12 c.m. (4·2″ and 4·8″), all without recoil and almost all shielded.

(*d*). Heavy artillery (guns, howitzers and mortars), which may now be considered to belong to the normal armament of provisionally fortified positions. Medium calibres, such as 6″ and 8″ artillery, were found to be considerably more effective than heavy, such as 11″ howitzers, owing to their far greater accuracy.

(*e*). Hand, and mechanically-thrown bombs and grenades, and land mines.

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Recent introductions in the form of *equipment* include balloons and kites; field telegraphs (electric and optical) and telephones; field photography; shields, searchlights and automobiles. The dirigible balloon and its opponent the automobile equipped with a light gun or machine gun, the combination of aerial kites with photography for the survey of hostile positions, and the proposal of shields for infantry (which has probably been settled by the introduction of the sharp-nosed bullet) have also to be taken into consideration.

GENERAL PRINCIPLES.

Little alteration is to be noticed in the general principle of the fortification of field positions. There are still the *skirmishing line*—the trenches of the front line; the *local reserves*—the closed works of the second line and their attendant batteries; the *general reserve*—the rear position; and sometimes *reconnoitring parties*—advanced posts.

The centre of gravity of the defence has now moved forward from the line of works to the front trench line, this is due to the improvement in weapons, which require, for full development of fire effect, the wide extent of trenches, rather than the limited faces of works. The defenders of the trenches must now feel that everything depends on them, and must no longer glance back and think of their own retirement, as they used to do when they felt that the decisive battle would be fought out somewhere in their rear. The line must be reinforced with small works as nuclei of resistance in order to give solidity to the trenches. These works will be little more than rings of trench work, surrounded by obstacles, which must not in any way differ in appearance from the rest of the trenches, and must be so sited that they can bring heavy fire to their front, and strong, concentrated, flanking fire over the intervals between them.

The line of works of stronger profile in rear must not be abandoned. If the front line is penetrated by the enemy, this forms a strong retrenchment, from which artillery and rifle fire and counter-attacks can be brought to bear on the front and flanks of the advancing enemy, in order to cause their earlier success to end in their complete destruction.

The ring trenches of the front line must not be replaced by open works or lunettes, which are vulnerable from the rear and easily turned. There is no reason why the closed works should not be quite unrecognizable from the front, when one takes into consideration the numerous subsidiary works, such as communication trenches, blindages, latrines, etc., which lie in rear of a modern defensive line of trenches.

The advantage of *advanced posts* was confirmed at Nanshan, Port Arthur, Liao-Yang and elsewhere. They may fulfil purely reconnaissance duties, and are then most conveniently placed in advance of the flanks, as being more easy to retire from, and tending to increase the circuit of a hostile turning movement. They should be fortified with open works, and their defenders, though making an obstinate resistance until the enemy arrives within 400 paces or even later, should not await a bayonet fight.

Advanced posts may also be intended to act as *caponiers* to the main line, to bring flanking fire along its front or to facilitate counter-attacks.

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In this case they must be very strongly fortified and obstinately held. It is in rear of such posts and under the concealment of the hills, villages or woods which are included in them, that so-called "dagger" or "stabbing" batteries of field or machine guns may be placed to enfilade the approaches to the works of the first line.

Flank reserve positions are prepared in rear of one or both flanks as a protection against turning movements. It is important that these should be in echelon, and not placed obliquely to the main line, for the latter does not in any way increase the circuit of a turning movement. With large forces several such positions may be prepared.

Rear positions, intended to cover a retirement, used to consist of lines of strong points. The general opinion of those who took part in the war is that they should now be considerably strengthened and reinforced with rifle trenches and gun pits. Their object is, with a comparatively small garrison, to develop to the utmost the surest means of defence—the strongest possible rifle and artillery fire.

Subsidiary and reserve positions should be occupied by guards, in order to prevent them from being forgotten, as happened at Mukden. In this connection great importance attaches to notice boards, finger posts and lamp-posts, to keep the troops from losing their way.

Technical Requirements of Works.

Passing now to the technical requirements of various works, the experience of the war has shown :—

i. That the thickness of earth cover, both in parapets and roofs, must be increased.

ii. That the command of all works must be reduced, even down to nothing, if the field of fire permits.

iii. The relief of works (*i.e.* the distance from top of parapet to bottom of trench) must be increased.

iv. Careful measures should be taken to protect the men against the very destructive, *indirect*, hits of shrapnel and splinters.

v. Concealment from view, and consequently from fire, must be arranged, the enemy's observatories and balloons not being forgotten.

vi. Obstacles of all kinds should be used as much as possible.

vii. Accuracy of fire at long and short ranges must be provided for, by measuring ranges, setting up distance marks, preparing range tables, and carefully organizing observation stations. The latter may be outside the sections of the position to which they belong and should be provided with observatories and signalling appliances.

viii. Lastly, facilities for working at night must be provided, searchlights, star shell, automatically-lighted flares, especially near obstacles, rifles and guns laid in special directions, communications for the reserves, marked by arrangement, easily recognizable in the dark, telephonic and telegraphic communication between sections, etc.

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Night attack arrangements include the counter-illumination of the defensive position to paralyze the action of the defence lights; a most careful technical reconnaissance of the ground; the preparation of the most direct approaches and their careful marking, even to the posting of men along them; the provision of means for crossing artificial and natural obstacles, and telephonic communication as in the defence.

It may be taken as a rough rule that, with large forces engaged and provisionally prepared works, the normal thickness of parapets should be calculated to give protection against the shells of 10·5-c.m. and 12-c.m. field howitzers. With small positions and hasty defences parapets should be proof against field guns. If it is probable that a position of the latter type is likely to be converted into one of the former, the fact should not be lost sight of in designing the works.

Fundamental Requirements of Works.

The fundamental requirements of various works are as follows:—

i. *Rifle Trenches.*—Fields of view and fire as large as possible, allowing no dead ground within 600 to 850 paces. This must be arranged by siting, as clearing the foreground is laborious and unsatisfactory. Choice of profile to suit the comfort of the riflemen. The two service types which allow of "firing standing from a step" and "standing in bottom of trench" are preferable. Some people recommend arm-rests, but they are inconvenient for "behind cover" firing, when the rifle rests on the parapet and is held by the left hand under the butt. Secure protection from shrapnel bullets, splinters and rifle bullets in frontal, reverse and enfilade fire, and also from the flight of splinters from shells which burst in the trench. The normal interval between men in the trench must be 1½ to 3 paces, and they must be protected with loopholes, overhead cover, *bonnets* (mounds between loopholes), light lean-to roofs and mined shelters. All kinds of traverses are necessary; recesses for the riflemen are not enough by themselves, as the gangway along the trench must be protected at intervals from enfilade fire. The trenches must be made as invisible as possible, by adapting them skilfully to the contour of the ground, masking every part of them, and, in provisional fortification, by the use of dummy parapets. All sharp edges and turns are to be avoided, and no subsidiary works should show above the front parapet. Uninterrupted *communication* along the trench without interfering with the men firing is a necessity, and men passing along this gangway must be defiladed from the view of hostile observers. Communication with flanks and rear is necessary, and if there is no time to dig a communication trench all the way, the safest line should be marked by signposts. If there is time to add a few obstacles in front of the trench, so much the better.

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ii. "Strong points" or works. Conditions similar to trenches, with addition of an obligatory obstacle, swept by frontal, or better by flanking fire. But parapets must be thicker, blindages stronger and trenches deeper and wider. Safe observation posts for sentries are obligatory. Men spaced at 2-pace intervals. "Refuges," *i.e.* trenches placed in rear and to the flanks, connected with the work, for accommodating three-quarters of its garrison during a bombardment, are obligatory. A work should contain living rooms for officers and men, dressing station, telephone office, store room for military stores, and latrine. There should be a supply of water and provisions, also repairing materials, sacks, poles, planks, etc. The drainage is important, and masking more important than with trenches.

Strong points (ring trenches) of the front line and rifle trenches must naturally support each other, the former being thrown slightly forward. If works of stronger profile are required in the front line, they must be open works—lunettes. Even on the flanks they should not be closed works, but should have closed works supporting them in rear. All the works of the second line should be closed works. Trenches between works may be somewhat concave in trace when viewed from the front.

iii. Machine-gun emplacements require the same conditions as rifle trenches, and especially an accurate knowledge of ranges. Owing to their mobility, machine guns should be provided with many spare emplacements.

iv. Artillery entrenchments require a distant field of fire up to 4,400 or 5,500 yards, and a near field of fire up to the guns themselves in exposed siting. There should be no dead ground. There should be protection for the detachments from all kinds of fire, masking, dummy screens, communications, and obstacles on three sides of the battery. Also in concealed siting the preparation of the foreground, observation stations, referring objects, etc.

v. Cover for reserves requires concealed siting, simplicity of design, convenience of communication with front and rear.

vi. Obstacles must be :—

(i.). Large enough in width, height and extent to form a real impediment.

(ii.). Round closed works they must be continuous;

(iii.). Their distance from the work (40 to 50 paces, and not more than 75 to 100) must not be too great to allow them to be conveniently observed and swept with frontal, and better still with flanking fire; but should be sufficient to safeguard the work from hand grenades thrown from beyond the obstacle.

(iv.). They must be of rapid construction, available materials and simple design.

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(v.). Passages through them must be protected by traverses of the same obstacle.

(vi.). They should be especially designed against the means the enemy is likely to adopt for crossing them.

(vii.). They should be masked either by making them match their surroundings, or by the use of dummy screens.

(viii.). Portable obstacles should be simple, light and cheap convenient for packing, fairly reliable for stopping the enemy, and capable of being set up quickly, and even in the immediate presence of the enemy.

FORTIFIED POSITIONS.

The author exemplifies these requirements by producing examples of:—

(i.). The provisional and

(ii.). The hasty defence of an imaginary piece of ground for a small force, consisting of 1 regiment (4 battalions) of infantry, 8 guns, 8 machine guns and 100 cavalry. The extent of front and the depth are each about 2,300 yards, which is about double those of former days, before the improvement in firearms required wider spacing.

In spite of the war experience that fortified positions are turned and are not attacked in front, the study of a position of this small extent is useful training. The position is suitable for the occupation of an advance or a rear guard, and as such it may be first met with by the enemy's advance guard. If it is strong enough to stop this, no turning movement on the part of the enemy will, probably, be possible until his main body begins to arrive. The delay thus caused will give time to the defenders to bring up their main body and to form on this convenient *point d'appui*, or to retire under its protection.

As regards the entrenching of large forces extending for several miles the great fault of the Russian positions in the war, from first to last, was their continuity—they were uninterrupted, continuous lines of works. The correct method of entrenching a large force, and that long since adopted in Germany, is the line of so-called "tactical or strategic fortified groups" or "rayons."

These rayons are of greater or less extent according to circumstances approximating to those shown in the examples. They are sited within supporting distance of one another. They require comparatively little labour in their construction, and do not impede the freedom of manœuvres of the army which rests on their support. The resistance which they offer to an advancing enemy will give the rest of their side time to form on them for defence, or to retire under their protection. But they must be held obstinately, and their defenders must pay no attention to local successes of the enemy in their vicinity. The defence of Sandepu against Grippenburg's attack, in January, 1905, is a good example of the value of such a *point d'appui*.

Occasions may occur when a second and even a third line of groups

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may be necessary; this is when both sides become involved in a war of positions, as occurred at Mukden, and which a commander should avoid by every means in his power.

Part II. deals with details of the construction and siting of the various elements of a fortified position.

Artillery Positions.

Chapter I. studies the tactical conditions of artillery positions. The Russians used exposed artillery positions in all the battles down to Telissu, and also at Port Arthur. In the fighting on 16th May, 1904, near Nanshan, a Russian battery had hardly appeared in an exposed position when it was struck by such a storm of shell fire from Japanese concealed batteries that in a quarter of an hour it lost all its officers and a half of its men, without firing a round.

The tactical considerations required in artillery positions are:—

(i.). The greatest possible field of fire both in width and depth; and

(ii.). The fullest co-operation of the fire of artillery with that of infantry, with a view to leaving no dead ground in front of the position.

Artillery positions may be "free," from which fire may be directed through a wide angle of front, or "restricted" to some definite object, such as the enfilading of an approach or the command of some river or ravine.

Concealed positions are only admissible when they satisfy these conditions. Otherwise the guns must be placed close behind the natural crest, for the abuse of concealed positions leads to an enormous expenditure of ammunition with little fire effect. Positions may be:—(i.). Open. (ii.). Masked. (iii.). Concealed.

In "*open*" positions, where the guns stand not more than $3\frac{1}{2}'$ below the crest, there is a large field of fire; direct laying; no necessity for special observers; no cover from the enemy's view and fire; difficulty and danger in occupying and evacuating the position.

"*Masked*" positions may defilade:—(*a*). A man standing ($5\frac{1}{2}'$). (*b*). A man on horseback ($8\frac{1}{2}'$). (*c*). The flash of a gun ($14'$ vertically below crest). In (*a*) the guns must be rolled up by hand, in (*b*) and (*c*) they can be drawn by horses. In (*a*) and (*b*) the flash is visible, in (*c*) only dust, and the smoke of bursts at the muzzle, which in Manchuria averaged from 2 to 3 per cent. In (*a*) the goniometer is not necessary, in (*b*) it is necessary, but the commander can watch the firing from a platform, and no special point to lay on is required, while (*c*) requires a specially prepared observing station. In all these positions the guns are discovered as soon as they open fire, and can be destroyed by the system of searching rectangles. This is avoided in "*concealed*" positions where the guns stand at a distance of 400 yards or more in rear of the crest.

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Guns may be masked by woods, villages, buildings, bushes, crops, and hayricks, etc., and thus concealed positions may be found on level ground and even on the front slopes of hills. A succession of crests, or of other masks, is extremely favourable. Even concealed emplacements must be thoroughly entrenched, and every form of cover provided for the detachment. Shields only reinforce earth cover. Concealed positions require well-organized observation of fire, accurate passing of orders, and some technical preparation of the position and the ground in front.

There must be two observation stations for each battery or brigade, one to the front for the observers and the other near the battery for the commander. They may be placed on hills, in which case they require solid and well-masked, splinterproof cover, or in trees but not in isolated ones. Trees which just show over a crest or high buildings, preferably in the middle or back positions of villages, are also suitable. Artificially constructed observatories should be sited so as to admit of observation just over the crest line.

For communication, telephones should always be replaceable by visual signalling. Special signals are better than spelt-out words, being more rapid and less likely to be read by the enemy.

It is also necessary to select subsidiary points to lay on, and to prepare an accurate plan of the whole position. This is the duty of the artillery officers.

The war showed that batteries should be scattered as much as possible and should be provided with spare emplacements to which the guns may be moved if the enemy discovers the original ones. On the flanks batteries should stand in echelon, to enable them to be swung round if necessary. This may also be necessary in front, where a wide field of fire is desirable.

The difficulty of sweeping with fire the dead ground in front of the guns, caused by the screen over which they are firing, may be met in various ways :—

(*a*). By selecting a position commanded by the enemy (the more the ground rises to the front the less dead ground there will be).

(*b*). By drawing back the battery, at a distance behind the crest of the screen.

(*c*). By posting infantry in the dead ground.

(*d*). By combining the positions of batteries in order to sweep over another's dead ground.

(*e*). By placing some of the guns in caponier positions to sweep the dead ground.

(*f*). By combining the posting of guns and infantry to allow of no dead ground. The last two methods are the most practicable.

Infantry standing 700 yards in front of artillery are safe from the effects of premature bursts of shrapnel. In this case the battery must be so sited that, at the least necessary elevation, its shells will clear the crest of the obstacle by twice a man's height. At this same least elevation they should strike the enemy not more than 1,600 yards in front of the

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defending infantry, *i.e.* the extreme effective range of the latter. Thus the site of the battery may be found experimentally, but the line of sight from it to the enemy's position should always pass 10′ to 14′ below the crest of the obstacle, to give the battery concealment from the enemy's balloons.

Experience showed that guns in concealed positions must cease firing on advancing infantry when it arrives within 600 yards of the defending infantry. It is then intended that two guns out of each 8-gun battery shall be rolled up to a direct position. It is doubtful whether this would be possible, as they would be overwhelmed by the enemy's artillery fire. It is suggested that it would be better to detach some guns from the first for this object, and to put them in carefully concealed positions, where they would lie hidden until required for this special object.

The infantry escorts, at the rate of half a (double) company per battery, should be placed under the orders of the artillery commander, and can be used by him if necessary for replacing casualties among the ammunition numbers, etc. The escorts must entrench themselves where they can best protect the battery; in the case of concealed positions this will probably be on the covering crest, in front of the flanks, and in front-line batteries, to right and left of the emplacements.

The use of dummy batteries, and the careful disguising of actual ones, were fully emphasized during the war on numerous occasions.

The use of "scouting sections" of artillery, *i.e.* the detachment of a few guns into false positions in advance of the flanks, is advised. These positions should be carefully concealed and arrangements should be made for the rapid transference of the guns from one place to another.

Guns of heavier calibres are best sited on the flanks. They require good roads of approach and firm ground, and all the other conditions of ordinary gun positions. In every group of heavy guns it is advisable to add a few machine or field guns for use at close ranges.

Cover for Guns.

The next chapter deals with modern designs for artillery entrenchments. On all occasions entrenching, if not for guns, at any rate for the detachments, is obligatory. The best type is that which provides a separate emplacement for each gun, at intervals of not less than 30 paces. The posting of guns in pairs is not so good, and in battery behind a single bank, worst of all. In these latter cases intervals between guns should be from 13 to 17 paces.

Emplacements may be made for:—(i.). Gun, detachment and wagon, or (ii.). Gun and detachment only, with recesses to take the removable trays containing ammunition. The first should be the normal type, the second only being suitable to the advanced emplacements, with a view to not sacrificing the wagon as well as the gun in case of accident.

When guns are posted at wide intervals it may be necessary, with a view to their concealment from balloon observers, to connect them with a dummy parapet of brushwood or sods, which horses can push their way through if necessary.

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The interval between guns in echelon depends on the distance (front to rear) and on the required angle of training, to which must be added half the cone of dispersion of shrapnel bursting at the muzzle. If the required angle is 60° then :—

With distance	15	paces,	interval	must	be	60	paces	These figures are approximate and each includes 12 paces as half the width of emplacements.
,,	,,	30	,,	,,	,,	90	,,	
,,	,,	45	,,	,,	,,	120	,,	
,,	,,	60	,,	,,	,,	150	,,	

With an angle of 45° the intervals would be 35, 55, 75, 95 paces.
,, ,, 30° ,, ,, 30, 50, 70, 90 ,,

Howitzers require especially large gun platforms—a circle of 8 paces diameter, or a rectangle 8 paces by 4 paces. With mélinite charges they require cover for those making up the charges. Whereas artillery detachment trenches require overhead cover and blindages like rifle trenches, it is not generally advisable to attempt to protect the guns themselves in this way.

It should not be necessary to entrench the wagons of the reserve artillery park or any limbers, natural cover should be available for them in rear of the position.

RIFLE TRENCHES.

Trenches sited at the foot of a slope get the advantage of the full range of point-blank fire, but are difficult to connect with the rear. They are allowable when they can make full use of point-blank range, when communication is possible with the rear by means of folds in the ground, diagonally to the front, and when they are not commanded by the enemy. The parapets should be kept low, unless it is necessary to see over bushes or crops in front, or the soil is hard, clayey, rocky or full of roots.

Great lengths of trench are not advised ; they are difficult to apply to the ground and difficult to conceal ; if the range of one part is found, the whole is under fire ; if the enemy gets into one length anywhere, he spreads along the whole. A half-company trench, 150 to 200 paces in length, is about the limit.

There should be communication trenches to the rear, and in provisional fortification a communication trench parallel to the front behind a reverse slope, which would serve as cover and might be fitted with blindages. The garrisons of the front trenches could use it as a "refuge" during artillery bombardment. The sentries left in the front trenches should have specially strengthened, roofed, lookouts.

Boer rifle pits are not recommended. Supervision is lost, the men are separated and the position only thinly held.

There should be three to four sentry lookouts in each company trench. There must be lookouts at the ends to watch the flanks. The angle of a traverse is a good place for the recess, which must be strongly roofed, with a wide-angle observing slot (60° to 90°), and splinterproof shield

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at the back. The top of roof must not rise above the parapet. A stool for the observer is a convenience.

Cartridge recesses are easily made by knocking the bottom out of a cartridge box, and using the sides for revetting the recess. Allowance for 300 cartridges for each rifleman should be made. By pulling out a sod or two from the revetment of the interior slope, expense recesses for a few cartridges, or food, may be made.

When concealing trenches, it should be remembered that observers in balloons may attain the angle of 1 in 4, though more generally they are at 1 in 7, or 1 in 8. The back slopes of trenches facing the front must be disguised accordingly, while trenches at an angle to the front may require to be completely prepared for concealment.

Communication trenches should have the greatest possible relief, and should be as narrow as possible—2½′—provided a wounded man can be carried along them. A narrow trench is more quickly made than a wide one, and affords those passing along it better cover. At intervals of 10 to 15 paces, lengths of 4 paces should be widened to double width, to allow stretchers to pass one another. In the intervals between them there should be occasional niches, to allow men to pass.

There should be a large allowance of reserve trenches, and in these all forms of head cover may be omitted, as they will only be occupied in the later stages of the action.

Cover for Machine Guns.

The Russians had carriage mountings with shields, as well as pack mountings for their machine guns. Neither of these was quite satisfactory, and a low sledge mounting, which was improvised, was used with success. Sledge mountings are inconspicuous, light, very mobile, can be carried, or pulled, or mounted on pack animals or in carts, as desired.

Redoubts.

The thickness of parapets in Manchuria amounted to as much as 14′, 16′ and even 18′. The height should not exceed 2·9′ to 3·5′. The interior trench may be deepened to 7′, and the spare earth may be used as a rear traverse to protect against splinters. Outside ditches are the simplest of obstacles.

Sometimes the ditch is replaced by a belt of entanglement, sometimes the latter is added at a distance of 40 to 60 paces from the ditch as a protection against hand grenades. The Japanese attacks on redoubts in Manchuria were always preceded by a storm of hand grenades.

The most suitable shape of a redoubt is that which conforms best to the shape of the ground, in irregular curves, or broken lines with rounded angles, as flat as possible as a protection against the enemy's artillery fire. A broken gorge can be used for flanking the interval between one redoubt and the next.

Redoubts are nowadays so choked with traverses, blindages, etc., that the bayonet fight cannot take place within them. The front parapet is the place for this and steps must be arranged for the defenders to

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climb out to meet the attack. For this purpose stakes are driven in to act as steps, or stakes with wire, or poles, stretched between them. There is no use in preparing the gorge traverse to bring fire to bear on the interior of the work; it must however be made high enough to cover the defenders of the gorge from reverse fire.

Communication trenches across the rear of open works should have the rear side sloped off, so as to give no cover to the enemy if occupied.

"Whiskers," or wing trenches, gained a certain amount of popularity, partly because they gave some protection to the defenders of the work during a bombardment, and partly because they increased the development of frontal fire. They should not cut through the obstacle zone, and are better placed outside it with no connection with the redoubt except by the rear.

Large traverses must be placed at 12 to 15-pace intervals, and light splinterproof ones at an interval of 6 to 12-pace.

Some authorities say that rear traverses, as a defence against back blast, are as necessary in front faces as in the gorge, but they encumber the work and would give good cover to the enemy in a successful assault.

Observation posts for sentries must be supplied at the rate of not less that one in each face and flank, and possibly in the gorge also.

Blindage roofs, proof against high explosive shells, were made with a double layer of $8\frac{3}{4}''$ beams, and not less than $3\frac{1}{2}'$ of earth. Those proof against the shells of light field howitzers, were of two rows of 14" beams and 4·7′ to 5·9′ of earth. In order to burst the enemy's shells on the surface, they were generally covered with a layer of broken stones or iron plates, the latter being fastened down with pickets.

In works of this description communication trenches should be rather larger than usual, to allow of the more rapid transference of men from the "refuges" into the firing line.

The necessity of having in the work a small store of repairing materials is strongly urged. A supply of hand grenades, and niches for storing them in, are also required.

Searchlights should not be placed in works, but in the intervals between them. Telephone communication with the rear and with neighbouring works should be arranged if possible.

OBSTACLES.

In Manchuria obstacles of wire and explosives were most used. Those of timber and earth were more rarely met with, the first because of the scarcity of timber, and the latter because of the hardness of the frozen ground, and also from their weakness as independent obstacles. Stakes placed chequerwise, palisades, dams with inundations, and shallow military pits were never used.

Passages, of 7 to 25 yards in width, left through continuous lines of obstacles, may be covered by a traverse of the same obstacle placed in rear of the gap, or by letting the two ends overlap for some 12 to 24 yards.

Deep military pits, by themselves, are easily passed and may be used

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by the enemy to form a "storming parallel," as happened at Liao-Yang. They take very long to make, especially in hard ground, and their one advantage is that material for their construction is always available. Combined with even a weak wire entanglement they form a more useful obstacle. They should be made in not less than four rows, with steep sides and narrow intervals, and if they can be flooded with rain water, with stakes standing in them, they make quite a formidable obstacle.

Wire entanglements are better obstacles, especially with barbed wire. They have the advantage of being very little damaged by artillery fire, even when they are standing fully exposed in the open. The only effective means of making passages through them is by sending up men with wire cutters. If the entanglement is combined with pits, the men can find cover in the latter, but otherwise the Japanese used shields.

The Japanese wire cutters had handles about $4\frac{3}{4}'$ long. Capt. Modrakh has invented a simple cutter, which fitted on the end of a rifle, like a bayonet, can cut both loose and tight wires simply by stabbing at them. This invention has the advantage that the man using it is not disarmed, as he must be when using both hands with cutting pliers. The conclusion of peace before the invention was perfected, prevented it from being extensively tested.

The idea of cutting down wire entanglements by machine-gun fire, or covering them with bridges or such like, is impracticable.

A belt of obstacle is better 28', than 21', in thickness. It is better not to put the obstacle in a shallow trench with a glacis. But a concealed obstacle, which comes as surprise to the enemy, is of great value. Some concealment is obtained by coating light-coloured stakes with mud, or grass, or brushwood. They are best placed behind such cover as bushes or crops, which must not however conceal them from the defenders. If the bushes are themselves entangled with wire they form an obstacle very difficult to discover. In less important localities, and against cavalry, this obstacle may be quite low. When material is scarce, two or three rows of wire fence, with the wires not more than 7" apart, form a good obstacle.

If the supply of barbed wire is limited, the front row or the top and bottom horizontal lines should be made of it. Even cord has been used in entanglements on emergency.

The Japanese made some use of abattis. Its chief fault is the difficulty of concealment.

Electrically fired land mines and fougasses were extensively used and were very effective against attacks. Solitary mines do not stop an attack, there must be several rows, placed chequerwise, with 12 to 24 yards between rows.

Automatic mines were also used. "Shrapnel" mines threw bodies like shrapnel shells into the air, where they exploded on reaching the extent of some 10' to 20' of wire, by which they were attached to the ground. "Repeating" mines were arranged to fire three charges, the second 3' below the first, and so on at intervals of 10 minutes. These were intended to destroy men who took shelter in the craters.

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The following portable obstacles were extensively used:—

Chevaux-de-frise entwined with barbed wire.

Crow's feet chevaux-de-frise, made of three 6′ stakes, pointed at both ends, and fastened together at the middle, at right angles to one another.

Planks, studded with nails on both sides, either straight or in crosses.

Snares of thick wire, used in connection with the studded planks.

The chevaux-de-frise and crow's feet are useful for making obstacles on ice or frozen ground, or for erecting an obstacle in front of a ditch, in the presence of the enemy. When placed, they must be anchored to pickets and entangled. The nail planks are suitable for exterior slopes of parapets or for the banks of rivers, under thin ice. They were used at Port Arthur.

The Russian hand grenades had wooden handles, and the charge vessel was surrounded by two heavy lead rings. Their range was about 60 paces, while the broken fragments of the rings flew as far as 400 paces. The grenades were fitted with safety catches for convenience of transport.

ENTRENCHING TOOLS.

Tools must be of the best quality, heads of the best steel and helves of strong wood (beech or oak) or hollow steel. The helve should not be too short.

Infantry should carry—besides picks and shovels—axes, saws and wedges, chiefly for use with firewood, augers for use with trenails, tracing-tapes and compasses. Every officer and man should carry something.

Full-sized entrenching tools should be carried in light carts, or on pack animals, immediately in rear of the regiment.

SHARE OF ENGINEERS IN THE CONSTRUCTION OF DEFENCES.

The want of an authoritative statement as to the share required of engineer troops in the fortification of positions has led to many unfortunate misunderstandings, infantry has waited for engineer troops to make cover for them instead of setting to work themselves, with the result of quite unnecessary losses.

The experience of the war has shown how technical troops and appliances should be utilized, and whose duty it is to arrange for their use under various conditions.

In the case of hasty fortification, especially with a small force, the work must be done by the infantry themselves, from their own designs and under their own officers. The commandant of the force, with commanders of units, and artillery and engineer officers (if any), will carry out the reconnaissance of the position, and decide on the spot the general scheme of defence viz.:—artillery positions, sites of strong points on flanks and centre, general position of main defensive line, reserve and echeloned flank positions, advance posts, rear positions, specially important items in each section and what sections are most important to the scheme of operations.

The decision as to smaller details is the right and the duty of the

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section commanders. All officers should understand nowadays therefore the details of fortification of positions. Only theoretical and practical training on manœuvres can teach the army the peculiar faculty and aptitude for entrenching which was so lacking in the war. Eye-witnesses said that the troops dug well enough, but could not combine their work with tactical operations, the knowledge not only of *digging* but also of *fortifying a position* being possessed by few.

If there are engineers in the force, their *rôle* is that of skilled assistants, to assist those in charge in their calculations and instructions, in checking the accuracy of the work, and in avoiding mistakes. Engineer officers, if available, will be placed at the disposal of, and be subordinate to the commanders of sections; they cannot interfere with the responsibility of the commandant and the sectional commanders. Their men will be employed as the commandant may decide. They may deal with approaches or communications, or with rear or reserve positions, or with the defences of specially important strong points.

In the case of provisionally fortified positions, the engineers will draw out the project of defence in all its details and apply it to the ground, laying out all the work, (except the rifle trenches, which will be traced by the company commanders) and carrying out much of it themselves. The troops in this case provide working parties, and their commanders are only responsible for the accurate carrying out of the work allotted them by the engineers.

Special Occasions for the Use of Fortifications.

In an appendix the author enumerates some special occasions for fortifying field positions.

Positions for the Defence of Defiles.—Defiles may be open (river crossings), or concealed (mountain passes). These positions are required either to allow advancing troops to deploy from the march into battle order, or to allow retiring troops to close. In order to protect the mouth of the defile from the enemy's shrapnel fire, the position should be 3 versts (3,600 yards) in front of it.

When the enemy can advance up both banks of a river, the position covering the defile becomes a double *tête du pont*.

A position in rear of an open defile is intended to prevent the enemy from using it. The position should then be within the range of effective rifle and artillery fire from the defile. It is more effective if the obstacle (stream or marsh) takes a curve concave to the direction of the attack.

Positions in rear of concealed defiles are intended to prevent the enemy from debouching from them. The works should be protected against plunging fire.

A position within a defile is intended to obstruct the enemy's advance. It should be placed where the defile widens out or where two or more defiles join. A good réduit, or keep, is necessary to cover retirement, which is difficult.

Points of Disembarkation.—These positions are taken up and entrenched by the first troops who get ashore. The flanks may be protected by the

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guns of the fleet. With large forces there should be several lines, with a strong réduit to facilitate re-embarkation. A position to oppose a landing is fortified like one in rear of an open defile.

Posts on Lines of Communication.—These include the base or "initial" station, the "head" station, "intermediate" stations, and sometimes also "concentration" stations, at railhead or where field operations begin. They must be protected from all sides, usually by girdles of detached strong points. A strong réduit, so sited that it will command the interior of all the other works is very important.

Positions covering railway stations, tunnels, and railway bridges, are similar to small posts on the lines of communication, blockhouses taking the place of strong points. Communication by telegraph or signal with the neighbouring points on the same railway line is important.

Fieldworks in the Attack of Fortified Positions.—Now that an attack lasts several days, the attacking troops must entrench in front of the defensive position, especially if their line of advance is obstructed, for instance by a defile. Such entrenchment will be used by the holding attack during a turning movement, which may last several days.

Parties of troops who have seized on some important tactical point in the enemy's position will entrench themselves while waiting for reinforcements.

The attacking troops should also prepare a rear position for use against a counter-attack, in the line of their first artillery position. From this they would work forward to the second artillery position, the whole operation being similar to the siege of a fortress.

ENGINEER TROOPS IN THE ATTACK.

Engineer troops in the attack will:—

(i.). Arrange for the passage of natural and artificial obstacles.
(ii.) Prepare approaches to artillery and rifle positions.
(iii.). Put in a state of defence important points captured from the enemy.

The reconnaissance of obstacles, and of the ground nearest to the enemy's works, is the duty of engineer officers. It is carried out by night by special reconnoitring parties, or by day, possibly, from observatories and balloons.

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THE NEW GERMAN INSTRUCTIONS FOR FORTRESS (SIEGE) OPERATIONS.

(A *précis* of a notice appearing in the *Militär-Wochenblatt*, No. 132, of the 22nd October, 1910).

THE publication of these *Instructions* fulfils a long-felt want. As the greater part of any force, put into the field in any future war, will have to deal more or less with fortresses, the issue of such regulations was absolutely essential. The training of all ranks and all arms in this important branch of military operations should be at least equal to that given with regard to other forms of military work.

It is interesting to compare these regulations with those issued in France, which were discussed in previous numbers of this paper.* The main principles are the same, and it is therefore scarcely surprising that the views expressed should, in most cases, be very similar in both countries. Both condemn a purely passive defence, and both consider that the closest possible co-operation of all arms alone holds out prospects of success.

The new German *Instructions* deal fully with the latest developments (*e.g.* wireless telegraphy, airships, aeroplanes, motors, etc.) likely to be of special importance in fortress warfare. It is pointed out that the attack of a fortress must as a rule depend upon purely military considerations. The fall of a fortress can only have a decisive effect upon a campaign, if the enemy's field army is seriously compromised thereby. It is also pointed out, in the introduction, that though the use of heavier armament may modify the outward and visible forms of tactics, the general principles of attack and defence remain essentially the same.

The first part deals with the attack. As a rule a formal siege can alone promise a successful issue. The enhanced importance of heavy artillery, engineers, and communication troops, is also alluded to.

The disposition of the besieging force must be as simple as possible. Various "sections" will be allotted to army corps, divisions, or brigades as the case may be. Those in which the decisive attack is to be made will be strongly occupied, while the others will be reduced by their comparative weakness to more exclusively defensive operations.

Great emphasis is laid upon the necessity for simplicity and method in organization, and upon unity of command. There are to be no semi-independent commanders of special arms (*e.g.* of heavy artillery or engineers) such as are contemplated in the French regulations. Such specialized arms will be represented on the staff of the officer commanding a "section," but he alone remains responsible for their employment.

* *Vide Militär-Wochenblatt*, Nos. 6, 7, 9 and 10, of 1910.

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The work and responsibility of a divisional commander are thus greatly increased (and with them, the necessity for previous tactical training), but such unity of command will ensure the close co-operation of all concerned.

It is pointed out that in some respects the choice of direction and method of attack is more restricted than in the case of ordinary field operations. In addition to considerations as to the general situation and the necessity for attacking a decisive point, the question of communications becomes a ruling factor. The colossal traffic, involved in modern siege armament, can only be successfully coped with by full-gauge permanent railways, which therefore largely decide the direction of the attack. It is essential that the operations should be correctly planned from the outset; hence the importance of full and accurate preliminary reconnaissance, in which full use will be made of airships, aeroplanes, etc.

An energetic advance to within the closest possible distance of the fortress will tend to facilitate and expedite subsequent operations. On the other hand the defender will probably have the advantage during this early phase, and the attacker may be thrown on the defensive—in which case he must select the best available line beyond the range of the artillery in the enemy's main position. These two principles are contradictory, but the *Instructions* leave it to the General Officer Commanding to do the best he can—*i.e.* to push forward as far as possible, without incurring useless losses.

As soon as it has been decided to attack a fortress, all arrangements must be made in the most methodical manner possible. Precise and suitable organization of troops, ground, transport, supplies, etc., and, above all, good communications of all kinds are essential. Accurate arrangements and clear orders can alone ensure smooth and expeditious handling of the enormous transport connected with a modern siege.

The duties to be carried out by the leaders and by the troops during the battle are then described in the German *Instructions*.

They point out once again that the difficulties of the attack are so great that they can only be overcome by the combined action of all arms working together for a common purpose, that infantry, though the chief factor in forcing a decision, is powerless to gain ground unless effectively supported by the other arms.

In the attack, the method of progression of the infantry is different to what it is in field operations. In field operations infantry move forward by sudden rushes from one position to another; in the attack on a fortress the infantry advance is most deliberate, and needs the assistance of both spade and rifle, and, while this advance is taking place, a number of guns, rifles and machine guns superior to that of the defence must strive their utmost to keep down the fire of the enemy. As it is essential for all arms to work together in battle, the German *Instructions* point out how necessary it is for each arm to have a clear comprehension of the conditions under which the other arms fight, and a knowledge of the effect to be obtained from their fire. All arms must therefore be trained to work in combination in peace, so as to be ready for what occurs in war.

The duties assigned by the German *Instructions* to the leaders are

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by no means easy to carry out. The leaders are responsible that the attack never flags. The difficulty of their task becomes apparent when it is realized that the battle will be of long duration, and that the increased effect of fire will compel the attacking infantry to advance by night and to resort to the laborious process of digging its way to the front.

The increased fire effect of modern weapons will also enable the defender to maintain himself in his advanced positions for a greater length of time than before, and will prevent the artillery of the attack from approaching to within effective range of the defender's main position. Consequently the attempt to capture the advanced positions will entail a fiercer struggle than hitherto, and it may be necessary to bring into action some of the heavy artillery of the field army in order to support the attack. As ammunition would also be required for this heavy artillery, such a procedure would occasion, at the very least, a loss of time and strength.

The German *Instructions* likewise state that the fight for the advanced positions will be particularly strenuous when those positions are situated so close to the defender's main position that his batteries in that position can join in the fight. So it may be necessary, even in these preliminary stages of the battle, to bring some of the siege guns of the attack into action.

The deployment of the artillery for the attack of the defender's main position forms, according to the German *Instructions*, the first phase of the final contest. For the advance of the infantry is of course quite out of the question until the guns are ready to open fire. But before the guns are in a position to commence firing much time must necessarily elapse, owing chiefly to the vast amount of ammunition which has to be collected. To open fire with single batteries as they become ready for action would involve defeat in detail, as the batteries would be overwhelmed by the concentrated fire of a superior number of guns. The artillery of the attack should not then come into action until it has sufficient ammunition and sufficient guns of sufficient calibre to engage the enemy, or until such time as the remainder of the artillery is ready to take part in the fight.

The opening of fire by the artillery is the signal for the infantry to advance at once and to push forward boldly. But not for long; a slower rate of progression will soon have to be adopted to avoid heavy losses, and this same reason will necessitate supports being moved forward only under cover of darkness.

To ensure all forward movements taking place simultaneously, all orders for the advance on the battlefield will be issued by the Commander-in-Chief, but the method of advance is of course left to section or other subordinate commanders. Should the enemy's fire render the usual method of advance impracticable, then recourse must be had to the wearisome method of advancing by sap. Such a course would be rendered necessary if the heavy artillery, together with the advanced field batteries of the attack, had failed to cope with the heavy armament of the defence. Such a case would be particularly likely to occur if the defender kept some of his batteries in rear of his main

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position, and so far back as to be out of range of the artillery of the attack. Under these conditions it would again be necessary to push forward some of the heavy batteries of the attack to enable the attacking infantry to continue its advance. Thus, in opposition to former ideas, the artillery of the attack will in future come into action at various stages of the battle, viz. (1) against the enemy's advanced positions, (2) against his main position and (3) against the batteries in rear of his position.

The German *Instructions* then deal with the support to be rendered by the engineers. The closer the attack approaches to the enemy's works, the greater will be the resistance met with. These works will probably be so powerfully constructed that artillery at a distance will be unable to destroy them. The infantry will find it impossible to force its way into the enemy's position unaided, and assaults by infantry at a distance of 150 or 200 yards are no longer feasible. Now is the time for the engineers to take an active share in the struggle. Under cover of infantry and machine-gun fire they will have to work their way right up to the enemy's positions.

Even then it is almost impossible to carry by assault a work which has not been destroyed. This work of destruction cannot be accomplished by the artillery for fear of hitting one's own side. It rests then with the infantry and the engineers to provide themselves with, and to bring into use the necessary engines of destruction.

It will thus be seen that the co-operation of all arms is necessary even in the final stages of the battle to overcome the defender's last efforts of resistance.

Part II. of the German *Instructions* deals with the defence of a fortress.

The greater fire effect of modern weapons enables the defender to hold on to his advanced positions for a greater length of time than before, provided these positions are within effective range of the guns in his main position. Heavy artillery should not as a rule be placed in the advanced positions, but mobile batteries of the field artillery reserve might, with advantage, be pushed forward in front of the main position and without incurring great danger. They would be protected by the guns of the heavy artillery.

The German *Instructions* point out that advanced positions are of great value for enabling the defender to discover his adversary's line of attack, and for preventing the enemy from seizing advantageous ground on which he could deploy his artillery within decisive range of the defender's position.

Should the defender compel the enemy to take up his line of investment at a considerable distance from the position to be attacked, to bring his heavy artillery into action against the advanced positions, and to fight a prolonged action to gain a favourable position for his artillery, he will not only have gained time but will have compelled a force, probably superior in numbers to his own, to be so tied down by the attack of the fortress that the plans of the chief commander of the enemy's main army in the field must be adversely affected thereby. Though the defender must offer a stubborn resistance, it is of great

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importance, both from a moral and a material point of view, that he should constantly adopt the offensive. The proper time to do this is when the assailants are still at a sufficient distance from the defender's mobile artillery, to enable this artillery to be brought into action against them without fear of its being cut off from the fortress.

The German *Instructions* state that the final decision should be sought for in the main position. Here they differ from the French *Instructions* which lay down that, when the governor of a fortress has come to the conclusion that the enemy is about to assault his *centre de résistance*, he orders that position to be evacuated and a fresh position to be taken up in the *position de soutien*. There is much to be said in favour of the French method. Its drawbacks are the following:—The danger of retiring too soon from the main position; the dividing up of forces (for some of the artillery must be kept in the rear position), and the consequent risk of the batteries in front being overwhelmed by superior artillery fire.

Finally the German *Instructions* deal with the methods of meeting the final assault. A successful result is only to be obtained by the most intimate co-operation of all arms in addition to the assistance to be rendered by neighbouring sections and by the general reserve. Works which have been captured must be recaptured, and every effort must be made to save the main position from falling into the enemy's hands. Even should this occur, the fight must not be considered at an end. Intermediate positions in rear must be occupied, and the flanks made to rest on works in the front line which are still holding out.

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USE OF SAP ROLLERS IN THE RUSSO-JAPANESE WAR.

Précis of an article in the *Injenerni Jurnal*, No. 11, 1910.

THE following is the description of a method of constructing sandbag breastworks, when in close proximity to the enemy, with the aid of sap rollers.

This device was used successfully with the 3rd Infantry Division of the Russian Army on the Sha Ho in November, 1904. The opposing forces were so close to each other (250—300 yards) that the operations were carried out almost under siege conditions. The ground was frozen to a depth of 3′ 6″, and attempts to construct flying saps had proved futile. The sap rollers described below were then resorted to. The rollers were made of iron or steel plate. (Thickness not stated). Each roller was 7′ long and 6′ in diameter. Two men could propel the roller easily over level ground. The method of employment is shown in the *Plate*. Briefly stated, the procedure was as follows:—

Three rollers were pushed out during the dark to the relative positions indicated on the *Plate*, and the following detachments were posted:—

8 men to No. 1 roller.
4 men to No. 2 roller.
2 men to No. 3 roller.

Three trucks, A, B, and C, were also placed in position.

The detachment of No. 1 roller took with them the ends of three ropes destined for use with trucks A, B, and C respectively; and, the detachment of No. 2 roller took the end of a rope for use also with truck A.

The ropes were marked at regular intervals so as to ensure that the correct distances were observed in the dark. When the rollers were in position, detachment No. 1 drew out truck A, which was loaded with sandbags. Under cover of the roller, the truck was turned so as to be able to travel towards No. 2 roller, and pulled by No. 2 detachment until just clear of No. 1 roller. Further supplies of sandbags were packed on trucks B and C and drawn out alternately to roller A, where they were off-loaded, and built into a breastwork by men working behind cover of truck A. As soon as the breastwork was completed behind truck A, detachment No. 2 would be signalled to draw this truck forward for its own length, and the process of building the breastwork was continued.

Casualties were replaced, and wounded men withdrawn by means of trucks B and C, which were only half loaded in such a case.

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NOTICES OF MAGAZINES.

Neue Militärische Blätter.

The Panama Canal and its Military Importance.—The construction of this canal has been so arduously pushed forward since 1907, that its opening is to take place in 1913, instead of on the 1st January, 1915, as the American Congress had announced.

Colonel Goethalz, of the American Military Engineering Department, who was entrusted with the undertaking in 1907, has freed from mosquitoes the strip of territory 10 k.m. wide which the U.S.A. possess on either side of the canal, built small townships all along the canal for the 44,000 labourers—of whom about 8,000 are whites and the remainder half castes, natives, Chinese and Japanese—constructed bakeries, washing establishments and other such necessary public establishments for them, and last but not least, has arranged for food and clothing to be supplied to them at cost price.

It was a moot point at first whether the canal was to be constructed at the same level throughout, or whether locks were to be employed. The former plan had been tried by the original Panama Company of 1881, which failed, and as it entailed an expenditure of time and money almost double that required by the second plan, it was abandoned. The canal will cost when finished 375,000,000 dollars, or £75,000,000, Its length will be 75 k.m., *i.e.*, 12 k.m. from Colon on the Atlantic Ocean to Gatun (this stretch is already navigable), then 15 k.m. in the Chagres Valley to Bohio Soldado, where the first lock is 20 k.m. further; at Obispo is the second lock, and the third, fourth and fifth in a stretch 13 k.m. long between Culebra, Pedro Miguel and Miraflores. The canal enters the Pacific Ocean at La Boca, 7 k.m. below Miraflores and flows for a length of 6 k.m. between two retaining walls into the deep water.

The question of the fortification of the canal has been the subject of heated debates in the American Parliament. Effective fortification will cost 14,000,000 dollars, and the proposal to make the canal neutral finds many partisans. The obvious disadvantage of this scheme is that it deprives the U.S.A. of all the strategical advantages which the construction of the canal would otherwise give them. Warships emerging from it are entirely at the mercy of the enemy whilst so doing, if they are not protected by land batteries. When protected, on the other hand, it is possible for the American fleet to pass from one ocean to the other and form up in battle array under the cover of the guns on the mainland, to oppose any enemy attempting to capture this vital artery. The canal will also allow the Americans of the eastern provinces to compete

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seriously with the English and Germans on the west coast of South America. Owing to the time (four months) taken and the risks incurred by ships in going round Cape Horn, the two countries mentioned above possess almost all the trade in western South America.

The proposed works consist of three batteries on the heights behind Colon, and of three batteries on the mainland on the Pacific side, and of the fortification of three islands near the heads of the retaining walls.

MILITARY NEWS FROM DIVERS FOREIGN COUNTRIES.—(1). *France.*—It is proposed to create an Inspector-General of Military Aeronautics who will have under his command all the aerial means of locomotion in use in the French Army, and the troops allotted to them. It is proposed to slightly diminish the number of officers who pass through the Staff College, and at the same time to increase the number of officers attached to the General Staff. The attached officers will be employed solely for office work, and by this means it is proposed to liberate from office work a large number of qualified staff officers, who will devote themselves solely to work in the field, and to the preparation for war.

A school for the higher professional education of field officers has been instituted, and on the 15th January, 1911, the first course begins. The class is composed of 20 colonels and majors, who are under the direction of the Commandant of the Staff College, and will be instructed by staff officers.

Norway.—Reorganization of the Army.—Before its separation, Norway relied almost entirely on Sweden to provide the defensive forces of the realm, and consequently has recently found itself under the necessity of drawing up a reorganization scheme for its army. This is to become law on the 1st January, 1911, and is very much on the following lines.

The army remains a militia force, with only weak "cadres" of professional soldiers. The levies pass through recruits' schools, are then dismissed, and later on undergo refresher courses. (Universal military service exists in Norway).

The army consists of the 1st Line, in which the time of service is 12 years; the 2nd Line (Landwehr), which cannot be employed outside Norway without the consent of the Storthing and of which the time service is 8 years, and the Landsturm in which all Norwegians between 18 and 50 are incorporated unless they belong to either of the above categories, and which would in case of need serve to replace casualties.

The permanent "cadres" consist of 1,700 officers, 2,700 N.C.O.'s and 2,100 men; the average number of recruits trained in a year is 11,000 or 0·44 per cent. of the population; when the Landwehr is also called out for refresher exercises, the strength of the army amounts to about 25,000 or 35,000 men, *i.e.* 1·12 per cent. to 1·5 per cent. of the population. The periods of training for recruits of the different arms are as follows:—Infantry, 72 days; cavalry, 126 days; field artillery, 114 days; fortress artillery, 72 days; engineers, 84 days; cyclists, 72 days. The refresher courses last 24 days. The times are very short.

Officers are trained in the Military College, which has two classes. The first class is followed by both professional and reserve officers, and

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lasts one year; the second lasts two years, and is solely for professional officers. Before entering the Military College, officers must go through the recruits' training in the ranks.

N.C.O.'s are selected from the ranks, and are trained in N.C.O.'s schools for four years. There is a higher military school with two subdivisions, one or the other of which is visited for 18 months—to train officers for the General Staff or for the Artillery and Engineer Staffs.

Up to now, the highest unit in the Norwegian Army has been the battalion; regiments of 3 battalions are now instituted. The land is divided into 6 brigade recruiting districts, which are further subdivided into regimental, battalion and company districts. There are to be 16 regiments, each consisting of 3 Line and 1 Landwehr battalions. The cavalry consists of 3 dragoon regiments (16 squadrons), and the field artillery of 3 brigades, or 27 batteries of 6 guns. The foot artillery consists of 4 companies armed with the 10·5-c.m. gun and the 12-c.m. howitzer, the mountain artillery of 3 batteries of 8 guns, the fortress artillery of 6 batteries, 1 independent company, 1 detachment, 5 signal and 5 mining detachments; the engineers of 1 sapper battalion of 5 companies, 1 telegraph battalion of 5 companies, and 2 bridging companies.

There are six machine-gun infantry sections of 4 guns each, and three cavalry ones of which two have 8 and one 4 guns. The cyclist companies become ski companies in the winter, are five in number, and are allotted to the cavalry.

The strength of units is as follows:—Infantry battalion, 986; squadron, 129; cyclist company, 126; field battery, 135; mountain battery, 158.

The field artillery is armed with the 1901 7·5-Q.F. gun (with long recoil); rate of fire, 20 shots per minute.

The present war strength of a brigade is laid down at:—2 or 3 infantry regiments; 1 cyclist or ski company; 1 machine company (dismounted); 3 or 4 squadrons cavalry with a mounted M.G. section; 4 or 5 batteries field artillery; 1 sapper company; 1 telegraph company; 1 company medical troops (bearer company); 4 or 5 field hospital detachments.

Russia.—A permanent airship committee of engineer officers is to be created.

£15,000 have been voted by the Russian Ministry of the Interior for the preparatory works of a railway through the Caucasus. Hitherto this project has not been carried out, owing to the insufficient knowledge of Russian engineers in the geology of the Caucasus and to their lack of skill in constructing tunnels. This scheme involves the construction of a tunnel 23·5 k.m. long. The railway would shorten the journey to Tiflis by 800 k.m. and thus, in case of trouble in Persia, troops could be brought up in a considerably shorter time than at present.

Football in the German Army and Navy.—The importance of sports is being more and more recognized daily in the German Army and Navy. Up to the present the great fear has apparently been that the mingling of N.C.O.'s and men on the football field would lessen the authority of the former over the latter, and thus be subversive to discipline. The

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captain of a company of the 116th Infantry Regiment at Mulheim on the Rhein has tried the system of encouraging his men to play football, and describes the results of his three years' experiences at great length. He is perfectly satisfied, finds that not only are his men more active on field days, but also that the ill-temper and lack of patience of the N.C.O.'s has disappeared, now that they are able to take healthy exercise after their long hours of wearisome drilling of recruits on the barrack square. The sense of discipline, far from being lessened, is increased. In the navy, football has for some time past played an important part, and every ship has, since 1908, its football team, whilst the game itself is looked upon as being of as great importance as gymnastics or physical drill. A league exists in the navy, the ships are played off against one another by squadrons, and the squadron teams compete for the Deutschland Shield, which was founded by Prince Henry. The marines also play football with great regularity.

New Terms in Aeronautics.—To comply with the modern spirit in Germany, *i.e.* to avoid as much as possible the use of foreign words, the Airship Association has invented a list of new words, for aeronautics, which are to replace the hitherto employed words of French extraction. These new expressions are as follows:—Aerial navigation (*Luftfahrt*) which can be divided into ballooning (*Luftschiffahrt*) and flight (*Flugwesen* or *Flug*). The latter expression includes all branches of flight, *i.e.* the technics of flight (*Flugtechnic*), actual traffic in the air (*Flugverkehr*) and flight as a sport (*Flugsport*). The means of locomotion in air (*Luftfahrzeug*) comprise:—Balloons (*Ballon*), airships (*Luftschiff*) and flying machines (*Flugzeug*): the word balloon (*Ballon*) imparts only the idea of the old spherical balloon, the newer cigar-shaped types, provided with means of propulsion are designated by the terms:—Dirigible balloon (*Lenkballon, Motorballon*); the use of these terms is however to be avoided and the term "*Luftschiff*" alone to be applied to these newer types.

Airships are divided into:—*Starrschiffe* (*i.e.* those without a ballonet or air bag, but with a framework) and *Prallschiffe* (those with an air bag). The ballonet or air bag is called "*Luftsack.*"

Flying machines are divided into mechanically-propelled aeroplanes (*Kraftflugzeuge*) and gliders (*Gleitflugzeug*). The former are further divided into *Flugdrachen* (aeroplanes) helicopters (*Schraubenflugzeuge*) and machines with movable wings, like birds (*Schwingenflugzeuge*). According to the number of its planes (*Tragdeck*) an aeroplane is a monoplane (*Eindecker*), biplane (*Zweidecker*), or triplane (*Dreidecker*). Each plane (*Tragdeck*) consists of two wings (*Flügel*).

Aerial navigators (*Luftfahrer*) are aeronauts (*Luftschiffer*) or fliers (*Flieger*). Certificated aeroplane drivers (*Flugzeugfahrer*) will when they have mastered all the difficulties of their profession and undergone the examinations receive the certificate of master flier (*Flugmeister*). The ascent is called with balloons, etc., *Aufstieg* and with aeroplanes *Abflug*.

Italy.—Four wireless stations of extra high potential are to be built in Milan, Turin, Bologna and Florence. They are on the system of a member of the University of Parma, Dr. Jacodello, which is based on the use of Volta's arc; the voltage is 40,000 to 70,000. The work on land

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to be constructed by the wireless detachment of the engineers. The fleet is also to be provided with these instruments.

Austria.—Two ski-patrols of three men each are allotted to each mountain battery, and one or two officers are allotted to each field artillery brigade or mountain artillery regiment as instructors in ski-ing. The military textbook: *Introduction to the Use and Military Employment of Skis*, which is used at the ski-courses is to be the textbook for these scouts till a further one is brought out.

A. H. Scott.

Revue Militaire des Armées Étrangères.

November, 1910.

The Career of the German Staff Officer.—The object of this article is to show the probable career of a German staff officer and the nature of his duties, and to bring out the great variety of these same duties owing to the perpetual peregrinations of the officers concerned between the Great General Staff at Berlin, the staff of army corps or divisions, and regimental duties. Since 1909, the number of officers annually admitted to the War Academy at Berlin is 160. The candidates must have at least three years' service, and specially good recommendations from their C.O.'s before they are even allowed to compete in the examination. As a rule about 700 officers compete at each examination.

The lucky 160, who pass the examination, spend three years at the War Academy at Berlin, and at the end of that time return to their units till the 1st April of the following year. They are then, according to the confidential reports rendered on them whilst they were at the War Academy, either "Kommandiert" (attached on probation) to the Great General Staff at Berlin, or recommended for employment as higher adjutants (corresponding to D.A.A. and Q.M.G. in the British Army) or merely left in their units. The latter fact emphasizes the real object of the War Academy: not merely to be a "Staff College" for the preparation of staff officers, but to be an instrument for the higher military education of the army in general. The latter class of officers, those who remain in their units, form according to the writer of an article in the *Überall* of May, 1910, a set of bitter and envenomed men who feel that they have been wronged, know better than everybody else, and are the terror of their comrades in arms. If such is indeed the case, it would seem as if the War Academy rather defeated its own purpose, and, instead of sowing higher education and good feeling in the army, planted the seeds of discontent.

To return to the staff officer proper:—Of the class of 160 who leave the War Academy, 55 or 60 are sent back to Berlin as staff officers on probation. They remain in this capacity one, two, or three years, and finally after a careful process of elimination, about 20 of them are appointed to the General Staff and promoted to the rank of captain,

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which generally means a gain in seniority on their contemporaries o one or two years. The officers on probation are attached to one o the other of the nine sections of the General Staff; the 2nd section (i charge of mobilization) is especially sought after, other sections on th other hand, such as the topographical and railway sections, are not muc appreciated.

The General Staff of the German Army consists of 312 officers and i divided into two large sections :—

(1). The Great General Staff at Berlin, composed of a head offic nine sections, and the historical and geographical departments.

(2). The staffs of the various larger units.

The staff officers are divided equally between these two branches.

The *rôle* of the Great General Staff is:—(1), To prepare for wa (2), to teach the army in general how to do this; (3), to ensure th uniformity of training throughout the whole army.

As regards its first *rôle*, the Great General Staff concerns itself "German military affairs" (mobilization, concentration, plans of ca paign against all possible enemies of the German Empire), the transp of troops by rail to the scene of operations (the details are worked out technical officers, who do not belong to the General Staff), milit organization and foreign theories on the conduct of warfare.

Its second *rôle* comprises the details of staff tours and the winter w of officers, and its third the education and training of the staff officers probation, and the execution of staff tours—directed by the Chief of t Great General Staff—by the staff officers of the various commands, that they do not get away from the central influence.

The organization of the staffs of the commands is as follows:—Th staff of an army corps consists of a "chief of staff" (colonel or lie colonel) and two or three staff officers, of which the senior is a major, a who are denominated as 1*a*, 1*b*, 1*c*, respectively.

The business of the army corps is classified under four headings:— (1), General Staff; (2). Adjutantur, *i.e.* D.A.A. and Q.M.G.'s departme (3), military law department; (4), supply, transport, medical, veterina and chaplains' services.

As in the case of the Great General Staff at Berlin, the staff officers the commands are purely occupied with things military and the trainin the officers. All technical details are carried out by administrative offic who do not belong to the General Staff. Thus their duties comprise marches, cantonments, tactical schemes and manœuvres, staff to mobilization, political matters, preparation of amendments to the trai regulations, maps, reconnaissances, military organization questions, armament of fortresses, winter essays of the officers and the supervis of proper tactical instruction of the men.

The Adjutantur on the other hand is responsible for the issue daily orders, garrison duties, the discipline of the troops, decorati recruiting, supply of men, horses, arms and ammunition.

On his definite appointment to the General Staff, an officer is gener sent to an army corps as 1*b* or 1*c* staff officer, and at the same time is the personal assistant of the chief of staff; thus he early acqui the necessary experience.

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In an army corps, the General Staff officers take precedence of the Adjutantur officers of the same rank, independent of the seniority of the officers concerned; in a division on the other hand, where there is only one staff officer (a captain) and one Adjutantur officer the senior takes precedence.

The post of staff officer in a division is one much coveted by staff officers, as it is one of the greatest independence. It is generally given to staff officers, who after their three years' tour as *1b*, have gone back to regimental duty, and spent three years as company, squadron, or battery commanders, and have then returned to the staff. It is generally when he is a divisional staff officer, that the staff captain gets round the "major's corner" the point in their career where so many German officers fail.

There is a special captains' promotion roster for the General Staff and thus these officers reach the rank of major very much earlier than regimental officers.

The positions now open, are either *1a* in an army corps staff, staff officer of a division, or a post on the Great General Staff. These do not, however, last for ever, and the return to regimental duty becomes necessary. This generally means the end of the staff career of the officers concerned, unless they are lucky enough to become chiefs of staff of divisions, or heads of sections of the Great General Staff. Even a chief of staff of a division has before promotion to major-general to revert to regimental duty and command a unit, and then—unless he becomes one of the five assistant chiefs of the Great General Staff—he no longer hopes for continual employment purely as a staff officer.

Theoretically the fact of having been a staff officer has no influence in the German Army on the selection of an officer for the rank of general, it is however needless to point out that an ex-staff officer has innumerable advantages over regimental officers, or even those who have been employed in the "Adjutantur," the accelerated promotion alone being one of the chief of these.

This was by no means forgotten at the recent celebration of the centenary of the foundation of the War Academy, an occasion on which several newspapers reminded their readers that the successes of Germany in 1864, 1866, 1870—1871 were due to the excellence of her military leaders, most of whom had studied at the War Academy and had been subsequently employed on the General Staff.

Foreign News of Various Countries.—*Austria.*—The corps of engineers (Militär-baubehörden) in charge of the construction, maintenance, etc., of all military buildings, except fortifications, has been granted military rank. Its *personnel* of officers is fixed in peace at:—1 field marshal—as head of the corps—2 brigadiers, 14 colonels, 16 lieut.-colonels, 22 majors, 75 captains, and 23 attached lieutenants.

The duties of this corps are in peace time to direct and carry out the construction, care and maintenance of all buildings other than fortifications, and in wartime to carry out, besides the above, the construction of fortifications under the direction of the Engineer Staff of the Army.

The peace duties given in more detail include:—(1), The planning,

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erection and maintenance of military buildings; (2), the purchase of lands intended for the sites of military buildings, rifle ranges, drill or manœuvre grounds; (3), the adapting of modern science to the building services. The officers are recruited from those who have successfully passed the engineers' course, for which all officers who have more than four years' service, or are less than 30 years old can be nominated.

The Engineer Staff is, in Austria, in charge of the fortified works as opposed to those looked after by the "Militär-baubehörden" mentioned above. To relieve this staff from the immense stress of work an auxiliary fortification *personnel* (Fortificationshilfspersonal) has been attached to it, composed of (1) reserve officers or ensigns; (2), foremen of works. The first class is to supplement the staff in time of war, and must have been through the engineering course for officers previously mentioned. It consists of reserve officers. The second class are taken from the foremen of works of the Militär-baubehörden, are specially trained at Vienna and are then granted exceptionally favourable conditions of pay and promotion.

Belgium.—The following are the details of the latest Belgian airships:—(1). "Belgium 3." The balloon is of the non-rigid type, the car is triangular in shape and 22 metres long; capacity 4,000 metres; there are two motors, which can be used singly or together, H.P. 110. (2). The "Brussels":—Capacity 8,200 metres, length 78 metres, two motors, each of 100 H.P.; three independent propellers. (3). A third dirigible is being built by the military authorities on the plans of the commander of the Air Company.

Holland.—The army at present possesses two machine-gun detachments each of eight guns. In September, 1909, the section stationed at the Hague made experiments on the adaptability of machine guns on motor cars in order to repulse landings. The result was most satisfactory.

Russia.—The following details are given on the new aeronautical school created in July, 1910:—The object of the school is to train officers for the air corps to carry out experiments in flying, and to keep the mobilization stores of the air units. It is composed of the officers' class, a permanent staff and a battalion, besides workshops, stores, and a museum. It is commanded by a major-general or lieut.-general, with an assistant field officer to look after the work of the school itself, and of the experimental sections. A field officer and four captains are also employed on the permanent staff.

The officers' class consists of 30 engineer officers, who have at least one year's service. They undergo a course of one year. Officers of other arms can also be nominated, but must subsequently spend two years in an aerial unit. If at the end of that time they are not qualified to be transferred to the corps of engineers, they are sent back to their units.

Turkey.—The staff college at Yildiz, is very much on the lines of the German one, previously described in this review. Special attention is paid to the study of foreign languages, notably French, Russian and German.

A. H. SCOTT.

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Rivista di Artiglieria e Genio.

November, 1910.

Fortification and the Offensive.—The authorized German periodical *Vierteljahrhefte für Truppenführung und Heereskunde*, published at Berlin, contains an interesting article under the title "Ingenieurkunst und Offensive," by General von Beseler.

The article in question does not contain new matter, but affirms principles which, thanks to the perseverance of military technical writers of all countries, are making rapid progress. These principles are treated in a very intelligent manner, and are of interest to the engineers not only of our own army but also to those of the great military Powers.

It would not seem inopportune to reproduce a portion of the writings of this brilliant German general, who, not belonging to the engineer corps and having no greater predilection for one arm of the Service than for another, shows a strict impartiality in his views.

"The German soldier has the 'offensive' in his nature. It promises to him fortune and victory. 'The lot of the assailants is always favourable,' exclaimed Frederick the Great in *The Art of War*. Who would wish to see this spirit of the offensive grow less in our army? Victorious defence is only a preparation for victory, not the complete victory itself. The latter is only accomplished by the blow which carries with it annihilation, beats the enemy, and places him in the power of the conquerors.

> Attaquez donc toujours, Bellone vous annonce
> Des destins fortunés, des exploits éclatants
> Tandis que vos guerriers seront les assaillants.

'War promises great things to those who know how to strike bravely,' proclaims the philosopher of Sans Souci to the conquerors of Mollwitz and of Hohenfrieberg, and this advice leads later to the laurels of Rossbach and Leuthen. It is not surprising that, in an army animated with such a spirit, methods of fighting which tend directly to the attack are viewed with the greatest favour."

The qualifications of the engineer, derived from an old Italian word signifying engines of war, lead to quite different conclusions. Originally the engineer was he who constructed and made use of engines of war for the destruction of the adversary's apparatus, and at the same time supplied the means of protecting or repairing the same engines; afterwards he became the constructor of fortresses.

With the invention of gunpowder and the perfection of artillery, there came a change, inasmuch as that all that related to destruction passed to the artillery, whilst the engineer devoted all his activity to the preparation of defensive dispositions, and finally to fortresses. Naturally, modern firearms influenced greatly these works. The author next gives some brief observations on the object and scope of fortresses in modern warfare.

A modern fortress assures the possession of a place in a limited sense only. The fall of a fortress—notwithstanding Paris—will not decide the close of a campaign, but recent history clearly shows that such a fall exercises a considerable influence on the political and military situation.

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If, at the moment of the capitulation of Paris, the French flag had still flown on the ramparts of Strasburg and Metz as it flew above Belfort, there would have remained serious difficulties to Bismarck's policy. Without the fall of Port Arthur the Japanese would with difficulty have attained their final conquests in Manchuria.

Again it should be remembered that the best organized army, with its mobilization accurately prearranged, always requires a certain period of time before commencing operations. Mobilization requires generally a few days, and operations cannot be commenced at the moment of the declaration of war as in 1870. During this time communications ought to be absolutely protected against the enemy's enterprises.

It is then that fortifications are of the greatest assistance to the mobile forces that are ready to enter into action on the frontiers, not only as lines of defensive walls, but also for strengthening the more important points on the lines of communication, the junctions of roads, the centres of railway systems, to cover the passages of rivers, mountain passes, etc., and the nearer they are to the frontier the more efficacious they are likely to prove. Frontier fortresses have also other important objects. They serve to cover the mobilization, and to hold open the passes for the invasion of the enemy's country, especially when the frontiers are at short distances from great rivers.

The crossing of a river in front of the enemy is always a difficult operation which may be rendered less dangerous, if not entirely overcome, by the construction of bridgeheads or works of protection in the vicinity. The undisturbed passage of a river in such circumstances is the first step towards a powerful offensive.

Everything depends also upon gaining time, but fortifications should never force troops to fight behind ramparts and ditches, but should guarantee for them the best use of the ground, the mobility and capacity of manœuvring, and thus the possibility of assuming the offensive. The maxim of Frederick the Great "Regarding fortresses it is especially necessary to consider the ground, since that is what essentially constitutes fortification" was, for a long time, not understood in its true sense. He did not mean, as is sometimes imputed to him, that the fortress should be adapted to the ground, but that the ground should be utilized so as to complete the fortresses. With that Frederick established the more important objective of fortification: he accentuated the using of the ground in the following verses in his *Art de la guerre*:—

> Vous trouverez partout des forts, des citadelles,
> Que les mains des mortels n'ont jamais travaillés,—
> Postes que la nature a seul ainsi taillés
> L'ignorant voit ces lieux, mais c'est sans les connaître.
> Le sage les saisit. . . . .

And when he wishes to inculcate on the commanders of troops the necessity of a proper use of the ground, for the construction of fortifications, he returns always to the same idea.

But Frederick extended this idea of action. The fortress under his masterly hand, formerly a work of passive defence, became a living system of combat. His maxims remained for too long a time misunder-

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stood, and it was only after the reawakening of Prussia that their value was appreciated. Even the works of Coblenz and Ulm have long been looked upon as antiquated, although their constructors fully grasped the importance of the reciprocal relation between the work and the ground.

The biased and inexact judgment which regulates field fortifications has, without doubt, led to a certain repugnance in the application of the offensive. In our regulation exercises for the infantry, the belief in this idea in opposition to the offensive spirit is obvious, since a warning against its dangers follows upon a timid counsel for its employment. Similar repugnance existed some time ago against all use of the ground; it was ever held as subversive of discipline for the soldier to kneel or lie down.

To-day it is impressed upon the officers and non-commissioned officers that they are not to expose themselves uselessly to the enemy's fire, but are to seek cover as much as possible; and this not on humanitarian principles but with the object of preserving for as long as possible their intelligence and energies. Occasions always remain when if they wish they may prove their heroism in the presence of the enemy. Our army has learnt to employ its cavalry and artillery efficaciously, and it can also now realize how greatly it may profit by the art of the engineer, and the work of the pioneers.

Naturally much depends upon the education and instruction of the engineer and the pioneer. Both should be founded upon a tactical basis. The commander of troops knows his work thoroughly only when he has a perfect knowledge of what the engineer can do for him, and is familiar with his services and those of his troops. In conclusion the author considers that the mistrust in the engineer should now cease, not only as regards the fortresses he builds, which are not now of a purely defensive character, but also of all his other methods of warfare. The duties of the engineer, as far as is necessary and practicable, should become part of the knowledge of the army.

Marshal Moltke, when speaking to General Neil who commanded the French troops in 1859, took occasion to show that the engineer who had directed the Siege of Sebastopol had succeeded because he understood warfare, and had made use of all means without distinction, whether by mine or sap, or by battle in the open field. The engineer who takes these words to heart will perform the highest of his duties, and will contribute towards the maintenance of the true spirit of the offensive in the army.

E. T. THACKERAY.

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BOOKS RECEIVED.

THE AEROPLANE. An Elementary Textbook of the Principles of Dynamic Flight. By T. O'B. Hubbard, J. H. Ledeboer, B.A., and C. C. Turner. 2s. 6d. net. Longmans, Green & Co., 39, Paternoster Row, E.C.

SPON'S ARCHITECTS' AND BUILDERS' POCKET PRICE BOOK AND DIARY, 191[illegible]. Edited by Clyde Young, F.R.I.B.A., and Stanford M. Brooks, L.R.I.B.A. 2s. 8d. net, post free. Spon & Co., 57, Haymarket, S.W.

SPON'S ARCHITECTS' AND BUILDERS' POCKET-BOOK. Memoranda Section. Edited by Clyde Young, F.R.I.B.A., and Stanford M. Brooks, L.R.I.B.A. 2s. 8d. net, post free. Spon & Co., 57, Haymarket, S.W.

LORD ROASTEM'S CAMPAIGN IN NORTH-EASTERN FRANCE. By Lieut.-Colonel Alsager Pollock. 2s. 6d. net. Hugh Rees, 119, Pall Mall, S.W.

THE GYROSCOPE: AN EXPERIMENTAL STUDY FROM SPINNING-TOP TO MONO-RAIL. By V. E. Johnson, M.A. 1s. 6d. net. Spon & Co., 57, Haymarket, S.W.

THE ELEMENTS OF TELEPHONY. By Arthur Crotch. 1s. 6d. net. Spon & Co., 57, Haymarket, S.W.

THE PRINCIPLES OF AEROPLANE CONSTRUCTION. With Calculations, Formulæ, and 51 Diagrams. By Rankin Kennedy, C.E. 5s. net. J. & A. Churchill, 7, Great Marlborough Street.

THE OUTLINES OF MILITARY GEOGRAPHY. By Colonel A. C. Macdonnell, late R.E. With 19 maps. 12s. 6d. net. Hugh Rees, 119, Pall Mall, S.W.

ELEMENTARY AERONAUTICS, OR THE SCIENCE AND PRACTICE OF AERIAL MACHINES. By Albert P. Thurston, B.SC. (LOND.). With 126 illustrations. 3s. 6d. net. Whittaker & Co., 2, White Hart Street, Paternoster Square, E.C.

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CORRESPONDENCE.

RESISTANCE AND "DRIFT" OF A BULLET.

DEAR SIR,

There appear to be two statements in Lieut.-Colonel R. de Villamil's article in the *R.E. Journal* for January, 1911, which are in need of some support.

(1). As to the drift of a bullet being caused by it rolling on the air, the explanation is very simple, in that the bullet on leaving the rifle has its nose pointing above its general trajectory. During its flight the bullet's nose is pointing very slightly above the trajectory; although the bullet is continually tending to conform to that trajectory, yet actual coincidence of the axis of the bullet, to the tangent to the line of flight at any one moment, does not take place. The result of this is to produce a partial vacuum above the bullet and a compressed layer of air below it, and it is owing to the layer of air below being of greater density, that the rotation of the bullet, with its grooves caused by the rifling, takes more effect on the under layer of air than on the over layer.

A bullet can be made to rise in the air in an upward curve against gravity. There are two ways in which this occurs.

(*a*). By a bullet ricocheting and turning head over heels in its flight so that whichever end of the bullet is in front is always travelling in a downward direction; *i.e.* similar to the spin of a golf ball.

(*b*). By a bullet becoming unsteady in its flight owing to ricochet, and afterwards going to sleep again but with its axis not parallel to its line of flight; if its axis happens to be pointing well above the line of flight, as sometimes happens, the bullet will plane up the air on its lower side until such time as it has effected a compromise between its direction of flight and the direction in which its nose was pointing at the time it steadied down. During this process the bullet is travelling in an upward curve.

(2). As regards drift being caused by gyroscopic action, this very plausible and simple solution was examined into in 1904 or thereabouts, and probably has been examined into many times previously. The only drawback to it is that the bullet happens to drift in the wrong direction to suit this theory.

Yours faithfully,

A. B. CAREY,
Capt., R.E.

The Editor, *R.E. Journal.*

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"DRIFT" OF A BULLET.

A REPLY.

SIR,

I have to thank Major C. E. Phipps, R.A., for his courteous criticism on my paper. *Du choc des idées jaillit la lumière.* I have also to thank him for the information that projectiles sometimes drift to the left—*i.e.* in the reverse direction to that in which they ordinarily move.

I am afraid Major Phipps' third paragraph must have been written in haste and without due reflection. I certainly ignored the effect of air friction, for the simple reason that I do not think friction enters into the question at all; but I did *not* consider the projectile as travelling *in vacuo*. A bullet travelling *in vacuo* and *precessing* appears to me to be, *almost*, a dynamical absurdity, since a *couple* acting in a vertical plane would appear to be a *sine quâ non* for producing drift in a flying bullet.

I have carefully examined the *Textbook of Gunnery* and I find:—

(1). The "proof" is no proof at all, but simply an "explanation"—just as mine was.

(2). The explanation is not in the least like the one I offered. The only point they have in common is that they are both based on gyroscopic effects.

(3). The explanation appears singularly unconvincing: it seems to me to be an exceedingly pretty argument in a "vicious circle."

As regards No. 1, I feel sure Major Phipps will not dispute my statement. A comparison of my explanation and that given in the *Textbook* should also decide No. 2. The *essential* difference is that I make use of gravity in the formation of a *couple* (which is certainly *capable* of producing precessional movement) whilst the necessary *couple* is produced in the *Textbook*, by some curious "sidelong position" of the projectile which "following its nose to the right" calls a vertical couple into existence. The whole argument therefore can be confined to No. 3; and as my remarks are, I am aware, rather strong I must try and show that they are justifiable.

After a preamble, which I omit, the *Textbook* says:—

"But the general effect may be attributed to the observed *tendency of the projectile* [italics added] to move with its axis nearly tangential to the trajectory." This is hardly a correct statement of the facts. The *tendency* of the projectile is to move so that its axis is at *right angles* to the trajectory. The pressure of the air tending to turn the point *away* from the line of the trajectory. As Professor Perry says, (*Spinning Tops*) referring to this subject, "this pressure tends to make the projectile turn itself broadside on to the air." As a projectile *does* keep its axis, more or less, tangential to the trajectory there must be (*according to this explanation*) some other *couple*—more powerful than that produced by the air pressure—acting in the opposite direction; and it is by no means clear how this couple is generated. But to continue:—

"To keep the point of the projectile continually turning downwards into the tangent of the trajectory, the projectile must be acted upon, as in

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the case of a top, by a couple whose axis is towards the centre of curvature of the trajectory."

There can be no doubt that this statement is absolutely correct, if—as is apparently assumed—the point of the projectile is always *above* the trajectory. Even if the point be *below* the trajectory the same, or a similar, couple must be acting *to produce the same precession;* though in this case it would be turning the point *away from* the tangent of the trajectory. How is this couple produced, however? The *Textbook* continues:—

"This couple will be *called into existence* if the projectile moves in a slightly sidelong position, with its nose turned a little to the right of the vertical plane of motion; and now the drift may be supposed due to the projectile following its nose to the right, and a deflection to the right of the vertical plane of fire thus accumulates in consequence."

The wording of this paragraph appears decidedly cryptic and I am afraid the writer is "begging the question." He started to show *why* the projectile turned to the right, say, and now he is *assuming the drift* to *bring a couple into existence which shall be capable of producing this drift.* This appears to me to be something very closely resembling a "vicious circle." Of course, *when the precession is started* a secondary action *is* produced on the bullet—*but, most unfortunately for this argument,* this action *tends to raise the point of the projectile:* not exactly what is required by this theory. Granted the precession this secondary action follows; but what *starts the precession?* Besides what right has anyone to *assume* the projectile should move "in a slightly sidelong position, with its nose turned a little to the *right* of the vertical plane"? It appears incumbent on the writer to show some reason *why* it has a preference for the right rather than the left. The expression "the projectile following its nose" would lead one to suspect that the writer had been studying the dynamics of a golf ball. The two cases are not on all fours, for there is no gyroscopic action on a golf ball, whose nose is moving about, having been caused to do so by one of the weird instruments used by the golfer.

I think, therefore, that I am not making too strong a remark when I say that the *Textbook* explanation is really no *explanation* at all of the cause of "drift."

The explanation I offered will account for *certain facts*, but, as Major Phipps most rightly says, it will *not* explain certain other facts (which I was unaware of till he drew my attention to them) and so, though it may be the truth, it is not the *whole* truth. This is no reason why it should necessarily be "scrapped": it is *capable* of explaining drift *in one direction*, but there are other factors which must be brought into the fighting line, and I will endeavour to give another (shall I call it supplementary) explanation, which I hope will account for *all the facts* given in the *Textbook.*

I must begin with the gun, since I am making an assumption; and I must consequently show it is a reasonable one and not in disaccord with probability. When the gun is fired the backward pressure causes a small rotation about some horizontal axis: the muzzle is very slightly jerked up and the block, or other support of the breech receives a blow. Almost immediately afterwards the reaction of this block raises the

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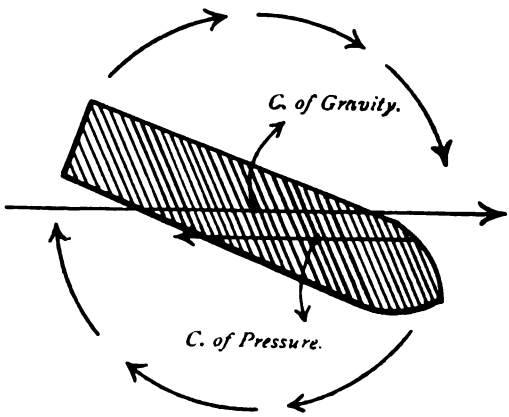
breech, causing the gun to rotate in the opposite direction about an axis passing through the trunnions: the muzzle is then very rapidly depressed. The projectile emerging from the muzzle, whilst the latter is rising rapidly, has its rear end raised a little so that its point is set *below* the line of the trajectory. This is my assumption, which is not in accord with the diagrams usually made of flying projectiles but appears to me to be a very fair one: besides it leads to a satisfactory solution of the problem, whereas the assumption of the opposite *does not*.



Next, the air exerts a pressure on the projectile tending to retard its motion. Since the projectile is inclined at a small angle (much exaggerated in the diagram) to the line of flight the centre of pressure of the air does not pass through the centre of gravity of the projectile but through some point *in front of it* (see sketch diagram). Lord Rayleigh has given a formula for calculating the distance from centre of gravity to centre of pressure for a perfect fluid but I am not aware that it has ever been calculated for a viscous one. The stress of the air forms a *couple tending* to cause rotation of the projectile in the direction of the circular arrows—to set it, in fact, broadside to the line of flight. Since the projectile is spinning rapidly about its principal axis, it resents having the direction of this axis of rotation changed and *precessional* motion takes place: the point turns out of the plane of the paper and towards the spectator. All this is quite elementary and can be seen with a gyroscopic top, or better still with a properly balanced gyrostat.

If this action were continued indefinitely the point of the projectile would tend to be set further and further away from the line of the trajectory, and this we know is not the case (see *Textbook*).

If we next examine the projectile in plan (sketch—also exaggerated), the arrow showing the line of flight and the curved arrows the direction of the precession. The pressure of the air here, as in the other case, is acting as a couple and tending to turn the point of the projectile away from the line of flight. In other words it is trying to *increase the precession*; and as Lord Kelvin first pointed out if you "hurry up the precession" of a top you cause it to rise up against gravity. Similarly,

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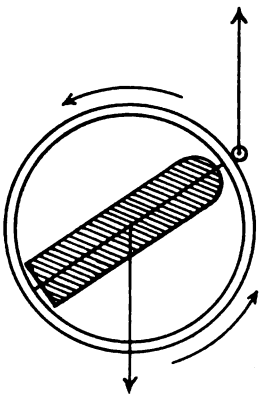
here, the air in trying to "hurry up the precession" causes the point of the projectile to *rise* towards the line of the trajectory: and not to be drawn *downwards* as described in the *Textbook*.



Granted the assumption all the rest follows, naturally, from the laws of rotation. We have two *couples*, one tending to force the point of the projectile downwards in the vertical plane, whilst the other tends to raise it: both however tend to turn it horizontally out of this vertical plane. If this continued indefinitely the point of the projectile would eventually be raised above the line of the trajectory, when a *reverse precession* would be started. The projectile, however, being inclined horizontally at a small angle to the line of flight is being acted upon by an accelerating force on one side so that it does not travel forwards in a straight line viewed horizontally but along a (kind of) parabolic curve: the spinning axis of the bullet getting nearer and nearer to the tangent of this curve so the deflecting force—that which forces it sideways out of the direction of flight—as well as the rotating force are gradually diminishing in intensity. Eventually the axis of the projectile will be, both vertically and horizontally along the line of the tangent to the trajectory. When this occurs all rotational stress will cease; nor will it come into operation again until the axis of the projectile gets out of the proper alignment.

The foregoing will I hope explain:—

(1). How the point of the projectile is turned out of the vertical plane.

(2). Why the axis, about which it is rotating is always kept very nearly in line with the tangent of the trajectory.

(3). Why "drift increases rapidly with the elevation" (*Textbook*), for the greater the elevation the more severe must be the blow, or pressure, exerted on the projectle as it is leaving the muzzle: and consequently the more must the point be depressed below the line of trajectory.

(4). "Counter-drift" or "reverse drift" (if I may coin a word) will take place whenever the point of the projectile rises *above* the line of the trajectory. I have no details enabling me to say how this actually is caused, but there are two *possible* causes:—(1). The projectile may be leaving the muzzle of the gun whilst it is being jerked *downwards*,

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(extremely improbable) or (2) if the action of "hurrying up the precession" is too violent the point of the projectile may not only reach the line of the trajectory but actually overrun it a little.

Crabtree's explanation I cannot follow. He says referring to the "hand gun" (page 53):—

(1). Spin of rifle bullet is left-handed.

(2). Nose of bullet is above the trajectory.

(3). "Wind pressure on the under side of the nose-end of the bullet *tends* to tilt the point upwards, but

(4). "Results instead, owing to gyroscopic action, in the bullet working over slightly *to the left*."

An experiment with a small gyroscopic top suspended, as shown, should convince anyone that the result is *exactly the reverse*.

I think the whole difficulty in understanding the subject of drift is chiefly caused by the *assumption* that the point of the projectile is *above* the line of the trajectory instead of *below* it.

Yours faithfully,

R. DE VILLAMIL.

February 8th, 1911.

The Editor, *R.E. Journal*.

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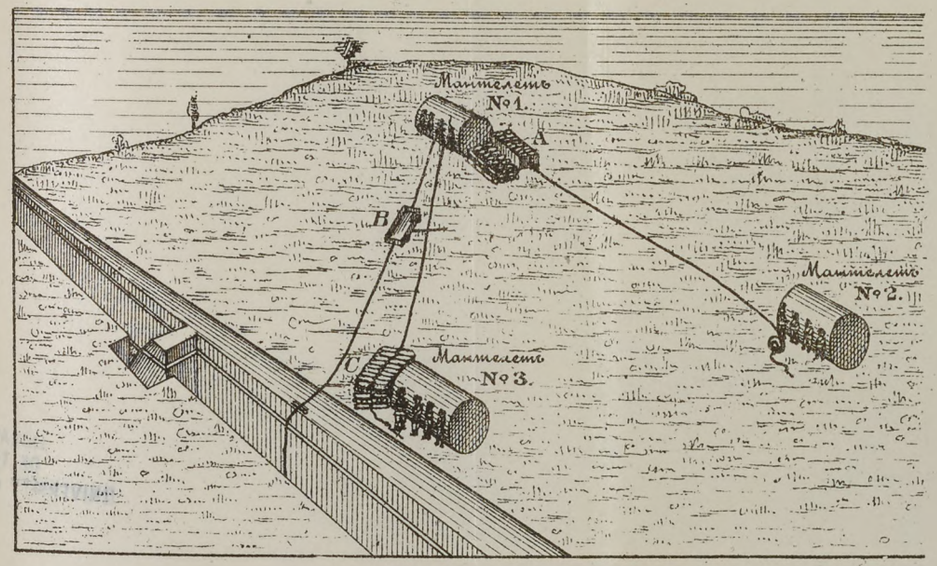
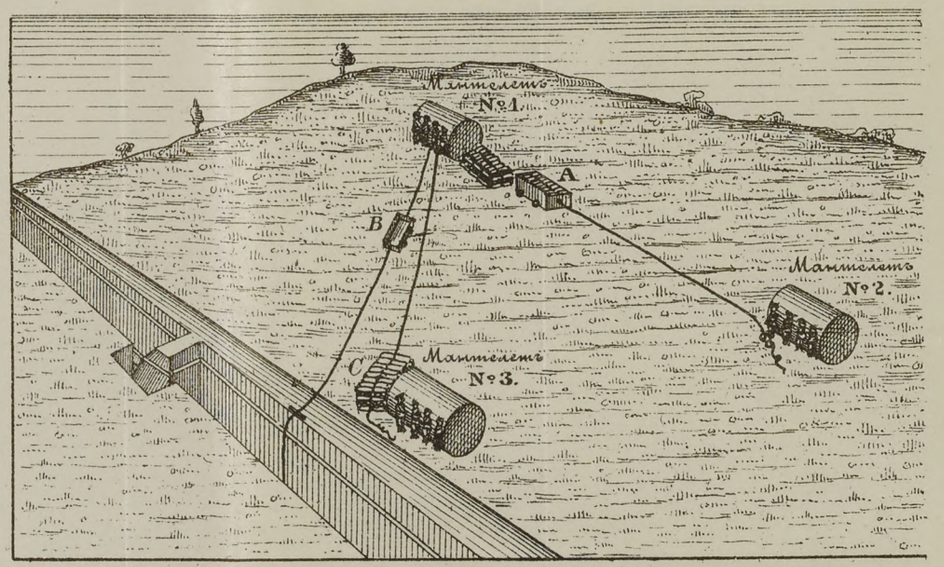
SAP ROLLERS IN THE RUSSO-JAPANESE WAR.

FIG. 1.



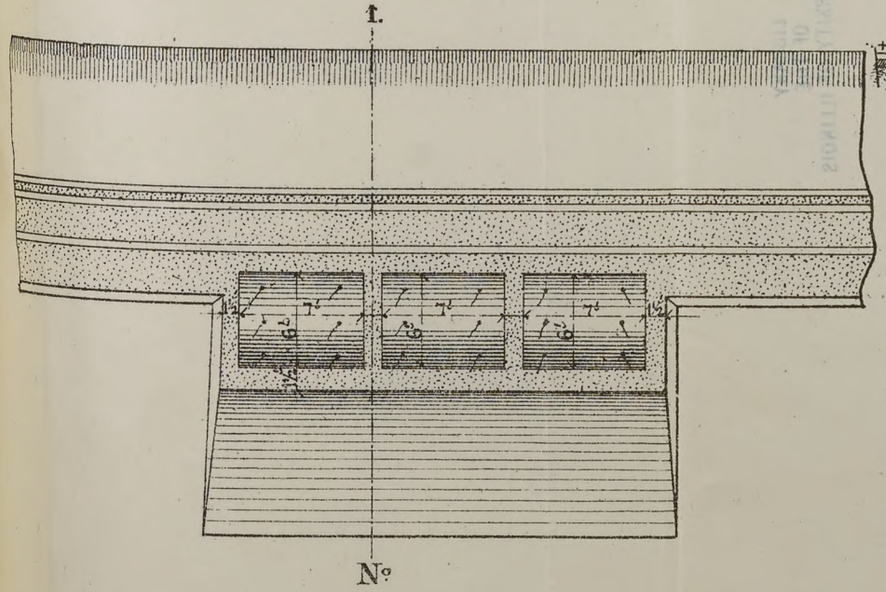
Securing the Mantlet.

FIG. 2.

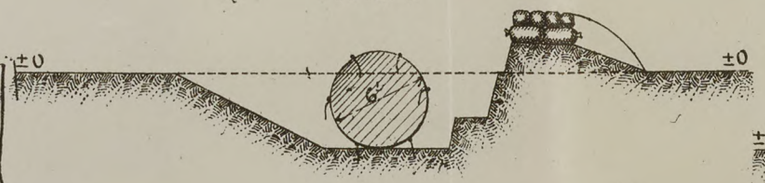


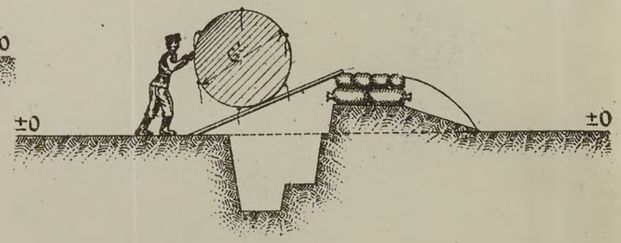
Rolling the Mantlet to the Top of the Parapet.

PLAN.



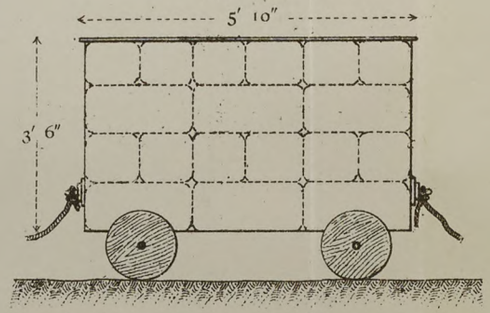
To No. 1.



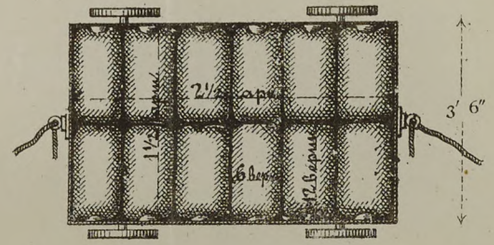


Truck A.

Side View.



Top View.



Description of the means for constructing Trenches with the aid of the "Flying Sap."

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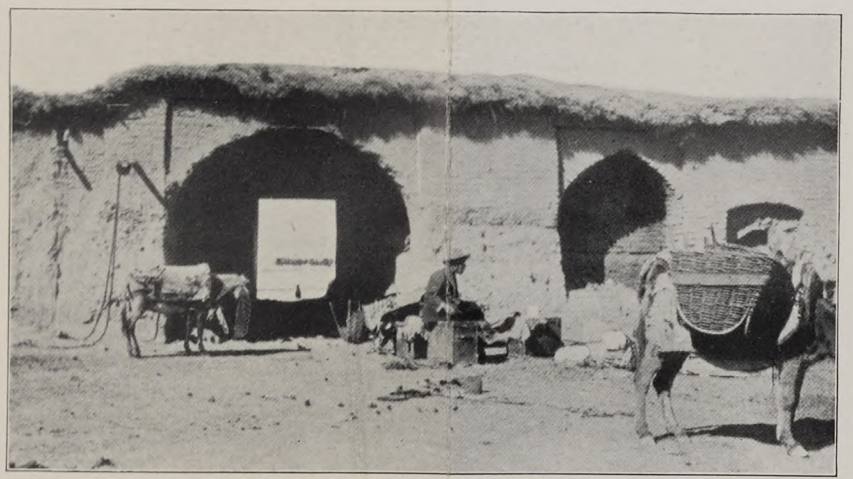
1.—A Posting-House on the Teheran-Isfahan Road.



2.—A Caravanserai on the Bakhtiari Road.

3.—A Stream on the Bakhtiari Road.

4.—On the Bakhtiari Road—the beginning of Trees.

5.—A Bakhtiari Family.

6.—Kaleh Tul and my Escort.

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SOME IMPRESSIONS OF A JOURNEY ACROSS PERSIA.

By LIEUT. J. F. GRAY, R.E.

I HAPPENED to be in Russia in October, and had intended to return to India at the end of my leave *viâ* Constantinople and Port Said, but the Fates and Turkish quarantine, which those who have experienced it say is an ordeal to be avoided, combined to induce me to change my plans at the last moment and to try a short cut through Persia. As I had not thought of this route until a week before leaving Russia, I was very vague as to how precisely I should arrive. Hence possibly a short account of the trip, and a little information as to ways and means of travel in Persia may be of interest to others.

Passing through the country from north to south, the general impression it produces is desert—dry, sandy wastes of camel-coloured desert, intensely hot when it is hot, and very cold at nights in the cold season. And the road just wanders straight on for hundreds of miles in an apparently aimless fashion, with a small village or perhaps only a caravanserai every 15 to 20 miles—wherever a little water is obtainable. Passing continually up and down the road are caravans of all sorts and sizes, camels, mules, ponies, donkeys and even cows, accompanied by Afghans, Arabs, Curds, Tartars and Persians, the latter with their women in long black "burqas" covering them from head to foot, with a white veil in front and a narrow strip of openwork over the eyes, sitting huddled up in wooden panniers, two to a mule, and the men, some walking, but mostly perched on top of a piled-up load on a mule. In the early morning—and they always like to start just before it gets light—the nature of a caravan is recognizable long before it can be seen by the sound of its bells; the tinkling bells of a poor man's few donkeys, the short-distance caravans with one or two deeper-toned bells, then the fuller notes of a big long-distance caravan, and lastly the deep boom of the big camel bells on a string of 200 or 300 of these out-at-knees-and-elbows looking beasts, silently padding along, each in the track of the one in front. It is a delightfully leisurely life, with nothing ever worth hurrying about, for, in Persia, time is still the servant and not the master of man; in the evening at a caravanserai the men sit round a fire smoking the Kalian or Persian water-pipe, whose steady gurgle mingles peacefully with a monotonous jingle of bells from the feeding animals.

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They are however very cruel to their animals, and it is the exception for a beast of burden to die in its stable; for if an animal is old or ill, why not make sure of one's money's worth before it dies? The result is that the roadside, especially in the hills near the tops of passes, is strewn with skeletons.

The towns through which one passes produce a rather sad impression of a country whose day is over, of former splendour and present decay. There are houses empty and tumbledown, bazars whose shops are only partially tenanted, some fine old buildings with wonderful old Persian tiles—but half the tiles are missing, broken or stolen—and, in the courtyards, gardens now uncared for and the characteristic strip of artificial water in a masonry tank whose sides are crumbling away.

To a casual observer the Government in Persia appears to be very incompetent, partly perhaps through lack of money, which is almost an essential of good government, and possibly the new *régime* has so far scarcely had time to prove itself definitely a success or a failure, but it seems that its Ministers spend most of their time in intriguing against one another, which can hardly be conducive to efficiency.

In common with other Oriental races the Persians have very little idea of the value of time. One might almost take as the motto of the Persian people "Farda Insha-Allah" (to-morrow if God will) which is the usual Persian reply to the question "When?", and of which a very free translation would be "Never do anything to-day which you can possibly put off till to-morrow." They are apt to be boastful as to past events and full of big talk concerning future events, but when it comes to the point, the actuality is usually very different and they are generally cowardly. I believe a saying is recorded of a famous Persian general some centuries ago "What fine soldiers we Persians would be if war were not a matter of dying."

I left Europe at Baku, whence I crossed the southern end of the Caspian Sea in a wretched little tub of a paddle-boat—rather dirty and crowded with passengers of all nationalities—to Enzeli, the principal Persian port on the Caspian. Enzeli is a collection of a few ramshackle houses on a narrow strip of land cut in two by the narrow entrance to a big shallow lagoon, known as the Murd-Ab (or Dead Water), about 7 miles across. This we crossed in a largish flat-bottomed boat with six rowers and a helmsman, helped by a sail and a light breeze, and were then towed up a small stream, almost in flood from recent heavy rains, between marshy banks covered with thick undergrowth and trees, all delightfully green, with flights of duck from time to time passing over our heads, to Pir-i-Bazar, which is a village consisting of a few wooden huts on a slimy mud bank. From there we drove in a two-horse victoria to Resht, a distance of about 6 miles. At Resht, where we had to wait two days to get a carriage, there is nothing of great interest; just an ordinary Oriental

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town, with narrow streets, none too clean, between mud houses, and in the middle of the town a big open space, the Sabz-i-Meidan, where there is a badly-kept public garden.

As the best hotel, the Hotel d'Europe, was full, I stayed at a hotel kept by a Russianized Persian, which was quite clean, and the local manager of the Imperial Bank of Persia was kind enough to give me most of my meals. He was shortly starting for home on leave and had a Goanese cook, who rejoiced in the name of Pascoes Joas Carvalho, whom he wanted to send back to India. This suited both of us, so I took him along with me and he proved most useful, as a man who can cook is a necessity after Isfahan, unless one is prepared to do one's own cooking.

Having procured a carriage, which I shared with another Englishman who was on his way to Teheran, we travelled straight through day and night for 57 hours to Teheran, only stopping at the various stages to change horses.

The first part of the road is pretty and very hilly—hills green and tree-clad at first and becoming gradually more rugged and bare as one climbs higher and further away from the rainy zone round the Caspian. It is a Russian road, wide and fairly well built, and the carriages are drawn by four ponies abreast. The ponies are underfed and overworked, but they contrive to pick their way up and down the steep hills at a fair pace, even in the dark.

Near Kasvin, where the Russians had then a garrison of some 1,200 Cossacks (I have since seen it reported in the newspapers that this number has now been increased by 600, though for no ostensible reason as Northern Persia appears to be absolutely quiet) after crossing the Elburz range at a height of about 7,500′, one arrives at the beginning of the true Persian plateau, which lies at a height of between 3,000′ and 5,000′ above sea level. The rest of the road to Teheran is dull and monotonous, over dry bare plain with low rocky hills, the only relief to the monotony of the scenery being the view from near Teheran of the snowy cone of Mount Damavend, which appeared a glorious pink over low blue hills in the light of the setting sun. Another not-to-be-forgotten feature of the road is that Kasvin contains a comfortable hotel kept by an Italian and his wife who cheered us on our way with a warm greeting and a good dinner.

We arrived at Teheran just after dark and so had to satisfy the police at the outer gate of the city as to our business and destination, before we were allowed to enter.

Teheran is a modern Persian town, fairly busy and for an Oriental town very clean, with some wide open streets with avenues of trees and a horse-tram running down one of them. I stayed at the English hotel, as the new Hotel de Parc—said to be better, and managed by a Belgian, ex-valet to a Belgian ex-Minister—was full. The next morning, hearing a band playing, I walked in its direction and found

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a small review of Persian troops in progress. The troops consisted of cavalry and infantry who did not march badly but looked a weedy lot compared with Indian troops, and the cavalry were mounted on small though wiry-looking ponies. It appears that recently their training has been carried out under a German military instructor and that there has been a great improvement in their drill at any rate, but they suffer from a lack of officers worthy of the name, and from pay that is apparently apt to be precarious. This review was taking place on the Meidan-i-Mashk, a big open space in the city used as a drill ground and surrounded by barracks. Not far from this is the principal square, the Meidan-i-Tup-Khaneh, *i.e.* Artillery Square, in the middle of which are some muzzle-loading guns surrounded by an iron fence, and on one side of which is a fine building occupied by the Imperial Bank of Persia (a British concern), and on another the office of the Indo-European Telegraph Department. Leading from this square, through large arched gateways, are some of the principal streets, in one of which, a wide avenue, most of the foreign legations are situated. Of these the most imposing is probably the British Legation, where, inside a wooded enclosure surrounded by a high wall, are the residences of the British Minister, Military Attaché, and other attachés. Owing to the very limited amount of leave left to me, I could only spend 24 hours in Teheran and then, having obtained a big and very ancient landau from the carriage contractor, drove straight through for three days and nights to Isfahan, a distance of about 360 miles. It is possible to sleep very comfortably in these carriages by filling up the well and spreading blankets on top, but it means getting up at each stage to worry the driver into bringing out the fresh horses quickly, otherwise the sleepy traveller is left to slumber peacefully in his carriage till daylight.

The road lies across the desert, for part of the way along the shores of a big salt lake, and for many miles the water is brackish. It is a dull monotonous road, hot and dusty, the posting houses and the few trees round them appear in the distance to float on a sea of heat haze, and in places the sand is so deep that the ponies can hardly drag the carriage beyond a walking pace.

I stopped for a few hours at Qum, a place of pilgrimage and sanctuary, where there is a fine mosque of great sanctity, containing the tomb of Fatima, with gilded domes and walls covered with blue tiles outside—the inside has never been seen by a European except in disguise—and a big bazar of narrow streets entirely covered in with vaulted roofs, through which there was only just room for my big landau without the two outer ponies to push its way through the crowds of people and donkeys. To add to the jostle there was also a religious procession carrying a gilded hand, a sacred emblem of the prophet Ali.

Then I stopped for a couple of hours at Kashan, formerly the chief

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centre of the Kashikari or Persian tile industry, famous too for a peculiarly malignant breed of scorpions, and where, four days before, there had been a fight of considerable severity—that is to say severe according to the standard of Persian fighting, which usually proves on investigation to be less bloodthirsty than reports make out. An extremely sporting freebooter of the name of Naib Hussein, who with a couple of hundred followers had been looting caravans right and left, had been besieged there by over a thousand Bakhtiari troops in the employ of the Persian Government, had kept them in check for several days, and then one night had quietly walked off with 500 mule loads of loot. The only damage inflicted by the Persian troops in their bombardment was to set fire to a workshop and kill a few non-combatants in the town.

At Isfahan I stayed with the British Consul-General, who was most hospitable. He was repaying a formal call on the Sadr-i-Ashja, one of the big Bakhtiari chiefs through whose country I had to pass, so I went with him. A Persian call is full of formalities and elaborate politeness, each person calling himself a humble slave and the other "Your Excellency." "How is the health of your August Highness?" "Thanks be to God by the kindness of your Excellency this slave's health is good." And so on for about 10 minutes after which it is possible in a leisurely fashion to get to business. We sat on three chairs for an hour or so, with a mirza (scribe) squatting on the floor with a roll of paper, pens, and ink, while a servant brought round small cups of tea and spiced coffee, and cigarettes for us, and a Kalian for the Sadr-i-Ashja. He made his mirza write letters to other Bakhtiari chiefs to look after me, and provide me with escorts for the road which was then considerably troubled by robbers who loot caravans whenever they get the chance.

Isfahan or Ispahan was the old capital of Persia, and in those days must have been a very splendid Oriental city—certainly the early travellers of the 17th century seem to have been very much impressed by its magnificence. Now it is but a memory of the past. The population is very much smaller than formerly, so that many houses in the outskirts of the city are empty and in ruins and there is a general feeling of decay.

The Chehel-i-Sutoun (*i.e.* House of Forty Pillars) contains some old Persian pictures on its walls, painted in the time of the great Shah Abbas, representing scenes of battle and court life, and a later picture depicting Nadir Shah in one of his battles. It was then the Hall of Audience and part of the Royal Palace, but was until recently used by the Governor of Isfahan as a storeroom, and is now very dilapidated and the garden a wilderness.

In the centre of the town there is a very large square, or rather oblong, about 500 yards by 200, the Meidan-i-Shah, with the remains of stone pillars which were used as goal posts, when, in more

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vigorous days, the Shah and his court used to play polo there; at one end stands the Masjid-i-Shah and another fine mosque at one side.

There is also the Madrisseh-i-Shah Hussein (Madrisseh meaning school) which consists of a large courtyard with a strip of water and some trees, surrounded by high walls and archways with domed roofs and two minarets, all covered with blue tiles. But that too is dilapidated though still used, and there are great blank patches where there used to be tiles.

Julfa, a suburb of Isfahan, contains a large Armenian population and an old Armenian cathedral, originally built about 250 years ago. The walls inside are entirely covered with paintings representing scenes of Biblical history from the Creation to the Last Judgment. Some of it slightly grotesque, but on the whole very effective.

The Consul has an escort of 20 sowars and a native officer from an Indian cavalry regiment; they had recently had to escort a British Consul from Shiraz to Isfahan and in doing so lost two of their number who were shot by brigands; they had however been able to follow them up and kill the two men who had fired the shots and their rifles, saddles and bridles now adorn the hall of the Consulate at Isfahan.

Having made a contract with a muleteer to supply me with five mules, three for my baggage and one each for my servant and self, to take me down to Ahwaz (260 miles across the hills) in 10 days, which is about the shortest possible time, I spent the next nine days on a mule's back, with intervals of walking. I was marching usually from just before sunrise to sunset, sleeping at night sometimes under an archway of a caravanserai, when it was not too dirty, and at other times in a small tent kindly lent me by the Consul at Isfahan. And it was thoroughly enjoyable, as the weather was almost ideal, though sometimes a trifle too cold at nights. I was escorted all the way by two Bakhtiari horsemen, each with a rifle slung over his shoulder and a bandolier full of cartridges, riding on highly ornamented but most uncomfortable little saddles with high peaks studded with brass nails, and on ponies that were not much to look at but very surefooted over the stony Bakhtiari hills. They amused themselves from time to time by firing at rocks from horseback at a gallop, and nothing seemed to please them so much as loosing off ammunition at anything. It is a country where everyone who can afford it carries a rifle, and one sees all sorts of weapons, long Arab guns with a barrel like a piece of gas pipe worn very thin and ornamented with brass and silver bands, old Martini black powder carbines, a few fairly modern cordite rifles of French or German manufacture, and some Mauser pistols. I was carrying a Colt automatic pistol, chiefly in order to have something to show to people, as they always ask to see one's weapons and are delighted to show their own in return.

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My first day's march consisted of 27 miles of flat plain between rocky hills with a certain amount of cultivation and groves of fruit trees, as water is fairly plentiful, and I arrived after dark and slept in a comparatively clean room in a caravanserai. All the next day, and it was a long march of 35 miles, the country was gradually getting more hilly, but bare and treeless. Halfway, at Ghavarukh, I had to get fresh sowars from the local Bakhtiari chief and while I was waiting was entertained by him with tea and fruits—grapes, melons and pomegranates—in a large room, bare except for Persian rugs, with the two principal Bakhtiaris and myself sitting on cushions on the floor, and all round a number of Bakhtiaris squatting on the floor with their rifles in front of them and a mirza to write letters, including some on my behalf to various Khans on the road. The result was that I did not reach my camp till 9 p.m., and then slept the sleep of the weary till 4 a.m. when I found it too cold for sleep. The next day the country became more interesting, hilly with a good many small streams, and a steep ascent and descent over a pass to a pleasantly shady grove by a village where I had tiffin. Then a stiff pull up and near the top trees to delight the eye—true they were not very large or very many, but still trees and a change from barren plains and bare hills. Then a steep zigzagging descent down a white chalk cliff, the Pass of the White Breast, and a glorious view of mountains with a silver stream cut deep into the rock several thousand feet below, hillsides covered with trees and numbers of hill partridge that made me wish I had a gun with me.

The fourth day was much the same with two stiff passes and a bad road along a dry ravine, with frequent ups and downs to avoid perpendicular cliffs, to a caravanserai at Shalil.

On the morning of the fifth day, after crossing a new iron suspension bridge over a narrow rocky gorge, there was a stiff climb to the top of a pass where things were really lively, two big caravans from each direction meeting at the top and through the middle of it all we were hustling our small caravan, while a little way down the slope was a group of Bakhtiaris firing shots at some thing or person on the opposite hillside. About sunset we came down to the swift Karun River, turquoise blue between low brown hills with a background of distant blue mountains, and from my open archway that night in the Godar caravanserai, I looked straight up a magnificent deep rocky gorge through which flows the Karun River, lighted up in the clear atmosphere by a nearly full moon.

On the sixth day, after crossing a small pass, we reached the real Bakhtiari plateau, fairly well watered, with a certain amount of cultivation and the rest camel-thorn. These Bakhtiaris are a hardy, vigorous race of highlanders, mostly very poor and uneducated and fond of fighting when there is a chance of loot and not too much danger. They wear a high egg-shaped felt hat without a brim and

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long locks that curl up from under the edge of the hat, loose nondescript clothes covered by a long-skirted coat, usually a knife in their belts and nearly always a rifle slung on their shoulder. Near each village there is a cemetery, and over the graves of tribesmen a stone crudely carved to represent a lion as a sign of valour. They are divided into clans, each directly under their own Khans, who are responsible to the various Bakhtiari chiefs, one of whom is the paramount authority. One of the chiefs represents them at Teheran, but they have very little respect for the wishes of the Persian Government, unless, as is the case at present, it happens to suit their own policy.

On the seventh day I made my midday halt at Kaleh Tul, a big fort with high mud walls flanked by towers, built on a mound with groves of pomegranates, and a village below it. There I had again to change my sowars and was given tea and pomegranates while I sat in a tent on the ground with the Khan and other Bakhtiaris, with my feet crossed under me—a position that is most tiring when one is not used to it—and endeavoured to make conversation in bad Persian.

The eighth day's march was over salt plain, with pools of brackish water and streams said to be undrinkable, to Jaru. From there next morning I crossed the last range of hills and dropped down to the flat, sandy plains of Arabistan. The inhabitants are Arabs, quite different to the Bakhtiaris in appearance, tall, lean men with hooked noses, who talk guttural Arabic and wear long flowing robes covered by a loose "aba" or cloak, and on their heads two rings of plaited camel's hair over a piece of cotton stuff, the ends of which they tie round their necks. They are horse breeders and nomads, living in black tents made of woven goat's hair, moving about with large flocks of sheep and goats, and owing allegiance to the Sheikh of Mohamerah and so indirectly to Persia. At one of their encampments an Arab pony and two mounted Arabs as escort, sent out by the British Consul at Ahwaz, were waiting for me. So I rode straight through the 43 miles to Ahwaz, covering 60 miles that day all together. My mules arrived the next afternoon, and I sent on my baggage and servant by "belam" or native sailing boat to Mohamerah, a port on the Shat-ul-Arab (the confluent of the Tigris and Euphrates).

Ahwaz is a small settlement, of Europeans mostly, adjoining the larger native town of Nasireh, on the river Karun, which is navigable, though shallow and full of shifting sandbanks, from Shuster, a little distance above, to Mohamerah. It contains a British Consul (at present a subaltern in the Indian Army), a Dutchman who is the Russian consular agent, a couple of Englishmen belonging to the firm of Lynch Brothers, some more Englishmen in the employ of the Anglo-Persian Oil Company—one of whom had lived for three years

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in a Curdish family as a Persian mirza without being discovered—a few white houses and some palm trees.

That was the end of my journey in Persia, except for an exciting motor drive of 60 miles across country, through deep sand, over thorn bushes 2′ or 3′ high, over patches of dried-up marsh, all at a speed of about 30 miles an hour, losing one nonskid band, breaking a mudguard and nearly upsetting by getting two wheels deeply imbedded in the pipe-line trench and having to push the car out backwards. We were driven by the pipe-line engineer of the Oil Company, with another man and myself in the back of the car hanging on like grim death, and in spite of that bouncing off our seats till our heads hit the cape hood above the car. Then 12 miles by river, partly in a native boat and partly in a petrol launch, to Mohamerah, where I dined with the British Consul and then went on board the British India mail steamer bound for Muscat and Karachi.

A project for a railway to connect Europe to India through Persia has recently been discussed in the newspapers. It appears that the route proposed is from Baku, skirting the southern shore of the Caspian Sea to Resht, thence through Kasvin to Teheran and on *viâ* Isfahan, Yezd, and Kirman, thence probably through Beluchistan south of Seistan to join the Indian railway system at Nushki, 100 miles S.E. of Quetta. The total length of line to be constructed is about 1,500 miles and it does not present any very great engineering difficulties, except the rise from sea level to roughly 7,500′ between Resht and Kasvin, and the difficulties owing to lack of water and scanty population in the desert region between Kirman and Nushki, where both labour and water would have to be transported over several hundred miles. It is proposed that the railway should be financed by combined Russian and British capital, the two countries having control of the line within their respective spheres of influence. As regards British interests, this railway, if constructed, should very materially assist trade from India, which is at present considerably hampered by the insecurity of the trade routes from the ports of the Persian Gulf.

It has been asserted that by this means Bombay could be reached in a week from London, but this seems difficult to reconcile with the fact that it is at present a 70 hours journey from London to Moscow, 64 hours thence to Baku, and 65 hours from Quetta to Bombay, or just over eight days, without allowing for 1,600 miles of single line from Baku to Quetta. Taking this at an average rate of 40 miles an hour (or 40 hours), and an accelerated through service *viâ* Vienna, it would probably mean rather under seven days to Quetta and nine days to Bombay.

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DETAILS OF JOURNEY.

	Conveyance.	Cost.	Time.	Remarks
Baku				British Consul. Hotel d'Europe.
to	Steamer Baku to Enseli. (Bi-weekly).	12 Roubles (£1 6s. 0d.)	36 hrs.	Fare includes 1 meal only.
Enzeli				
to	Carriage whole distance or	8 Tumans (£1 12s. 0d.).	4 hrs.	Carriages and boats must be bargained for.
	Boat to Pir-i-Bazar and thence carriage.	3 Ts. 2 Ts. } 5 Ts	6 hrs.	Toll of 1 Tuman near Resht
Resht				Hotel d'Europe. Imperial Bank of Persia. British Consul (an Italian).
to Kasvin and	Carriage.	Carr. 61 Ts. Toll 6 Ts.	36 hrs.	Rooms at post-houses on road. European Hotel at Kasvin.
			18 hrs.	Tip to drivers 2 krans per stage.
		Tot. 67 Ts. (£12 15s. 0d.)	Total 54 hrs.	
Teheran				Hotels de Parc and d'Europe. British Legation. Imperial Bank of Persia. H.Q. Indo-European Telegraph. Head Office of Lynch Bros.
to Qum, Kashan and	Carriage.	122 Tumans 1 T. (toll)	18 hrs. 18 hrs.	Rooms at Telegraph Offices at Qum and Kashan.
			34 hrs.	Tip to drivers 2 krs. per stage.
		123 Tumans (£23).	Total 70 hrs.	
Isfahan				British Consul-General. Imperial Bank of Persia. Indo-European Telegraph. Agent for Lynch Bros.
by Bakhtiari Road to	Mule Caravan.	10 to 15 Ts. per mule.	10 to 18 days.	Price of mules varies, being more expensive for a quick journey, and must be bargained for. Toll of 5 krans per laden mule. Ordinary rewards to escort 3 krans per man per diem, allowing for return journey. Servant and tent necessary.
Ahwaz.				British Consul. Imperial Bank of Persia. Office of Lynch Bros.
	Steamer (sailings uncertain) or Native boat.	Not known. 5 to 7 Ts.	48 hrs.	
Mohamerah				British Consul. Imperial Bank of Persia.

N.B.—Rate of exchange varies, but roughly £1 = Roubles 9.50 = Krans 53, and 10 Krans = 1 Tuman.

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THE USE OF MATHEMATICS TO A SOLDIER.

By LIEUT.-COLONEL C. F. CLOSE, C.M.G., R.E.

THIS paper is intended as a contribution to a discussion of the value of a mathematical training, at school and at the military colleges, as affecting the efficiency of an officer in his career in the Service. It is not proposed to take the high deductive line, or to begin by asserting broad principles, such as the alleged antagonism between the practical and theoretical types of mind, or the supposed superiority of the classics to the mathematics as mental training, or *vice versâ*, or the breadth of view which is, or is not, engendered by a literary training, or the clearness of thought which does, or does not, result from a study of science.

It is the humbler task of this brief paper to attempt an examination of two practical points bearing on the main question: First, what is the use of mathematics in war, or in preparation for war? And secondly, is there any common term in the upbringing of the famous commanders of modern times which will throw any light on the value of a mathematical training?

PEACE-TIME STUDIES WHICH REQUIRE MATHEMATICS.

It is not necessary to deal at any length with the various uses which officers of the Army find for mathematics in peace time. The chief opportunities occur in the domains of artillery construction and gunnery, engineering, electricity, and geography; all very necessary studies, but studies not confined to soldiers. There are some specialist studies, which, though not without a certain importance, might be left entirely in civilian hands. However, apart from narrow issues, it will be generally agreed that a knowledge of the principles of mechanics is, for example, essential to the engineer. The amount of mathematics he uses in his engineering will generally depend on his ability, but he must use some. The more he knows the greater his competence to deal with unusual problems. He cannot thoroughly understand what he is doing if he has not a bowing acquaintance with the calculus, although some engineers think they get on very well without.

There is no need to labour the point. It is recognized that a mathematical training is a desirable preliminary to the study of constructional engineering. In the allied domain of geography it is no less desirable. The mapping of the land surface of the globe is, with

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one notable exception, in the hands of the armies. Our own officers scattered throughout the world take a principal part in the systematic exploring and mapping of our enormous Empire.

As regards artillery construction and gunnery the necessity for a mathematical treatment of the problems dealt with will not be disputed, nor can there be any doubt that practical experience and mathematical theory must in this matter go hand in hand.

We shall not go far wrong, therefore, if we say that it is reasonable that there should always be available a number of officers whose mathematical training should fit them for the conduct and prosecution of certain ancillary duties and studies, duties and studies which are necessary as a part of the peace preparation for war.

THE USE OF MATHEMATICS IN WAR.

In war itself the direct value of mathematics, except mathematics of a very elementary character, nearly disappears. It may be as well, however, to note the sort of thing which may be wanted. There is, of course, for engineers the building of bridges, with the elementary calculations which this involves.

In *Forty-One Years in India* Lord Roberts gives an account of an officer who was ordered to make a bridge and busied himself so much with the calculations therefor, that in the meanwhile another officer had been ordered to build the bridge, and had finished it before the first man was ready to start.

There is another story, told of a certain siege. The C.R.E., being puzzled what to do with a junior officer, said, "He is a useless fellow, tell him to make a map of the place." So he was told to make a map. Time passed and the fortress was captured and somebody remembered the aforesaid officer, and he was asked what had happened to his map. His reply was to the effect that he had not yet cleared up a discrepancy in his base measurements.

The moral of these stories is obvious. Officers who do these things are totally lacking in a sense of proportion. One may also suppose that the individuals quoted were not very familiar with the work required. But both stories belong to a past generation. There is now an admirable examination which ensures that Engineer officers who are promoted to the rank of captain use the formulæ required in field engineering with perfect discretion.

Another class of calculation which may sometimes be required is that for the number of transport animals necessary for the supply of a force of a given size at a given number of marches distant from the base. There is, of course, no difficulty in stating the problem in symbols, making provision for the drivers' rations, mules' forage, and for spare mules. But for those who dislike symbols there is always the rhetorical method, which, however, for any considerable number of marches, is very laborious.

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There is at least one instance of the use in war of the method of taking differences. This method is well known in experimental work as a useful means of detecting errors and of ascertaining the probable existence of any simple law. Now, at Kimberley, at the outbreak of the South African War, the armament consisted of 7-pr. R.M.L. guns. These little guns were sighted up to a comparatively short range, too short to be of material value in keeping back the advanced positions of the enemy. It therefore became necessary to extend the range table. This was done by putting down the known elevations in minutes corresponding to known ranges in yards, and extending the table for a few hundred yards by taking successive differences. Of course there is no magic in the use of differences, but they must be used with discrimination.

Another practical use of mathematics in the rough business of war will be found in the application of the mathematical theory of trajectories to the problem of hitting aeroplanes and airships. Contrary to common belief there is no simple rule which gives the relation between height, distance, and elevation.

We may now sum up this portion of the enquiry by saying, that all the mathematics required, or likely to be useful, in war, is of a very elementary description. Obviously no aptitude at analysis is wanted. The higher flights of mathematics are, as a fact, of no value to the soldier in the field. In peace time they are blameless as a relaxation.

The Effect of a Mathematical Training.

We now come to the second part of this investigation which attempts to deal with a question of far greater importance than that discussed above, and this second question is, "What is the indirect value to a soldier of an aptitude for mathematics, and what is the indirect effect of a mathematical training on his habits of thought?"

As a means of finding an answer to this question it is proposed to examine the education and special aptitudes of the great commanders born in the 18th and 19th centuries. These are, Frederick, Washington, Napoleon, Wellington, Moltke, Lee and Jackson.

Frederick, 1712—1786.—Frederick was brought up rigorously; the system of education devised by his father being directed to making him a hardy soldier. At the age of 9 years every hour of his day was allotted to some definite occupation. He never learnt English, and was forbidden by his father to learn Latin. "Encouraged by his mother and under the influence of his governess and of his first tutor, Duhan, a French refugee, he acquired an excellent knowledge of French and a taste for literature and music."* His father, in his instructions for his education, laid down, "Die

* *Encyclopædia Britannica.*

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Rechenkunst, die Mathematik, Artillerie und Oeconomie muss er aus den Fundamente erlernen."*

Although he had a good grounding in elementary mathematics there is no reason to suppose that he had any special liking for the subject. His tastes lay in the direction of philosophy, history, poetry and music, precisely those things hated by Frederick William. He played really skilfully on the flute and amidst the cares of State retained his fondness for music. It is not surprising that, as a result of the system of education enforced by his father, Frederick should have had a particular affection for those studies and pursuits which were forbidden to him.

One of his latest biographers says that he showed himself "blind to the latent possibilities of natural science and mathematics." "Is it not true," he demanded of d'Alembert, "that electricity . . . has only served to excite our curiosity? . . . Is it not true that all the operations of chemistry are in the same case?"†

Washington, 1732—1799.—Whatever impartial historians, if there be such people, may think of the rights and wrongs of the quarrel between the American Colonies and the Home Government, there can be no question that the eight years' struggle between France and the Colonies on the one hand and Great Britain on the other produced only one soldier of eminence,—Washington. The Washingtons were of pure English stock, as is indicated by the name. Washington's great-grandfather settled in Virginia about 1657, and in Washington's time the family was amongst the foremost in the Colony. They were large landowners, and theirs were all the advantages of a cultivated Colonial society.

As regards his education it is reported that "at 13 years of age he had become quite a proficient in arithmetic, and entered upon the study of geometry."‡ About this time his half-brother Lawrence formed the project of putting him into the Royal Navy as a midshipman, but owing to the strong opposition of his mother nothing came of this scheme.

It was then decided to educate him as a land surveyor, and with this end in view he studied geometry and trigonometry for which he showed great aptitude. His calculations, books, drawings, and accounts are particularly noted for their accuracy and method. Up to the age of 16 much of his time was spent "in the study of mathematics to which he had become strongly attached, and in amusing himself by practically applying it in surveys and admeasurements" of the territory surrounding Mount Vernon.

When he was a little over 16 he was entrusted by Lord Fairfax

* *Friedrich der Grosse.* Halm. 1855.
† *Frederick the Great.* W. F. Reddaway. 1904. G. P. Putnam's Sons.
‡ *Life of Washington.* Upham. 1852.

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with the survey of the great Fairfax estates, and for the next three years was almost continuously employed upon surveying and exploring expeditions. Some of his own accounts of these adventurous journeys are still in existence. His biographers lay stress on the value of this training to him in his after career, as accustoming him to a hard life, giving him an intimate acquaintance with the frontier regions and their inhabitants, and giving him what is vaguely called an eye for country, *i.e.* enabling him to carry in his head true notions of the frontier geography.

At the age of 19 he was appointed by the Governor, adjutant-general of his district with the rank of major; his duties were to inspect the Militia and generally prepare for the struggle with the French which was seen to be impending. This appointment was no doubt due partly to family influence, and partly to his own force of character and fondness for soldiering and adventures. In 1754, when he was 22 years old, he was given the rank of lieutenant-colonel and appointed second in command of the military forces of Virginia.

He does not appear to have received in early life any instruction in modern languages. For, at the age of 22, in the affair of Fort Necessity, he was unable to read the French proposals and was obliged to rely upon an interpreter. He knew no Greek but it may be presumed that as a boy he was taught Latin. But, so far as we know, the only educational subject for which he had a special liking was mathematics.

Napoleon, 1769—1821.—Napoleon's academical career and aptitudes are extremely well known and have been often described. He entered the Military School at Brienne in 1779, when he was 10 years old, and remained at this school for more than five years, passing in September, 1784, as a *cadet-gentilhomme* into the Military School at Paris.

At Brienne his abilities do not seem to have attracted much attention, but he was studious and did well in mathematics. He had neither liking nor aptitude for grammatical studies. On leaving the school he was described as having "always distinguished himself by his application to mathematics."

He spent one year at the Military School at Paris and on leaving was thus reported on:—"Retiring and diligent, he prefers study to amusements of any kind, and delights in the reading of good authors; he is devoted to abstract sciences, with little leaning to others, is well versed in mathematics and geography; is taciturn, loves solitude, is obstinate, proud, and exceptionally inclined to egotism; speaks little, is energetic in his answers, ready and severe in his refutations; possesses much love of self, is ambitious and hardworking. This young man deserves to be pushed on."*

* *Napoleon as a General.* Yorck v. Wartenburg.

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A couple of his sayings of later life may here be quoted :—

"Military science consists in carefully weighing all possible eventualities, and then, almost mathematically, eliminating chance. It is here that no error must be made, for a decimal more or less may change everything. But this discrimination between skill and chance can only be exercised by a real genius."

"There is no mystery in arithmetic or in geometry. Of all sciences these most stimulate the mind."*

His latest biographer says :—

"Strangely, it may seem, both of them [Napoleon and Wellington] showed a marked taste for topography and for figures. Both gave much attention to exploration of ground and to map study; both had the gift of numbers. Wellington told the Rev. R. Gleig that his special talent was rapid and correct calculation, while Napoleon was a mathematician and seemed to think in figures."†

Wellington, 1769—1852.—All that we know about the tastes and aptitudes and studies of Wellington may be very briefly told. After spending a few years at Eton he was removed by his mother when he was 15 and sent to school at Brussels. After a year or two at Brussels he was sent to a military school at Angers where he spent one year. According to the *Dictionary of National Biography*, he had no turn for scholarship. It is certain that he was fond of music and played well on the fiddle. It may here be noted that his father, Lord Mornington, was a musician of some distinction.

He gave up playing the fiddle when in India on the ground that it was not a very soldierly accomplishment.‡ The only evidence of any other special aptitude is that of Gleig, who heard him say more than once that his special talent was rapid and correct calculation and that "if circumstances had not made him a soldier he probably would have become distinguished in public life as a financier."§

Moltke, 1800—1891.—Let us now turn to the study of Moltke's life and note what instruction he had when young and what were his special aptitudes.

Moltke went to the Royal Danish Academy when he was 11 years old and remained a cadet at that academy until he was 18. The course of instruction included higher mathematics, applied mathematics, fortification, chemistry, tactics, strategy, surveying, military geography and statistics, French, German, philosophy, drawing, and sketching. The subject in which he did best was mathematics.

At the age of 22 he entered the Prussian service and from the age of 23 to 26 he was at the War Academy in Berlin. In the report for

* *Maximes et Pensées*. 1820 ed., p. 40.

† *The Growth of Napoleon*, p. 350. Norwood Young. John Murray. London, 1910.

‡ *The Croker Papers*, I., p. 337.

§ Maxwell's *Life of Wellington*, I., p. 5.

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the first year the only subject in which his work was not described as "very good" or "excellent" is French. The subjects marked "excellent" were, mathematics, statistics, theory of surveying, and surveying. In the second year he studied spherical trigonometry, the elements of mechanics, the calculus, geography, fortification, German literature, tactics and strategy, surveying, French, and natural science. In the third year, the course consisted of military history, attack and defence of fortifications, general literature, General Staff business, and surveying. In the general report on his work it is stated that "He has written good essays on the practical military subjects given. The result of his scientific studies has been very good."

Writing in 1866, of his studies in the War Academy, Moltke says: "I was sent exceptionally early to the War Academy in Berlin, where the lectures of Major v. Canitz on the history of war, of Professor Ritter on geography, and Professor Irman on physics, interested me much."

In reading his biography one's attention is necessarily attracted to his liking for drawing. He was a skilful draughtsman, and his skill was not limited to landscape drawing. He drew admirable portraits. He was an exceptionally good topographer. For three years he served in the topographical division of the General Staff, working in Silesia and Posen. During his three years in Turkey he carried out surveys of the Dardanelles, Constantinople, the Bosphorus, and made maps of Varna, Schumla, Silistria and greatly increased the existing knowledge of Asia Minor by his exploratory surveys based on astronomical positions. When in Rome in 1849 he made the first accurate topographical map of the neighbourhood. Writing during the siege of Rome in 1849 he says: "I cannot help mentioning with great regret a magnificent pine tree (one of my best trigonometrical points) which grew close behind St. Peter's, but has been felled by the barbarian defenders, without any conceivable advantage." *

Briefly then, Moltke received a very sound and thorough general and military education between the ages of 11 and 25. In this education mathematics played no small part and he did very well in the subject. He was a good draughtsman and a keen geographer, and had a great fondness for music.

Lee, 1807—1870.—In General Long's biography† of Lee the first note as to his education is that he was taught to practice the strictest economy in all financial concerns. Early in life Lee had made up his mind to enter the Army and, with a view of going to West Point, at the age of 17 he entered a school in Alexandria to study mathematics. He did very well at this school and it is particularly noted that his diagrams to illustrate problems in conic sections were

* *Moltke: His Life and Character.* Osgood, McIlvaine & Co. 1892.
† *Memoirs of Robert E. Lee*, by A. L. Long. 1886.

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remarkable for accuracy and neatness. He spent four years at West Point, passing out second on the list, and was commissioned as a second lieutenant of engineers in 1829.

For the next five years Lee was employed on the construction of the fortifications for the defence of Hampton Roads. In 1835 he was appointed assistant astronomer on the commission for marking out the boundary between Ohio and Michigan, in 1836 he was promoted first lieutenant.

We find him next employed in making surveys, plans and estimates for the improvement of the navigation of the Mississippi. The river was "triangulated and sounded from the mouth of the Missouri to some distance below St. Louis."* For some years after this he superintended the execution of the navigation works. Then follow some miscellaneous appointments, and in 1846, when he was 39 years old he took part in his first campaign, the Mexican War.

Thus his early education was largely mathematical, it is known that mathematics entered considerably into the four years' course at West Point, and it will be noted that after leaving West Point he was for 17 years employed on engineering duties necessitating the use of mathematics.

Stonewall Jackson, 1824—1863.—All readers of Henderson's life of Stonewall Jackson will remember that Jackson had little or no schooling as a boy. In early life he is said not to have been clever, but persistent and painstaking, qualities which showed themselves in a remarkable degree when he was at West Point. He joined at West Point in 1842 when he was 18 years old, and, on account of previous lack of education, had a very uphill task. "'We were studying,' writes a classmate, 'algebra and geometry that winter, and Jackson was very low in his class. Just before the signal "lights out" he would pile up his grate with anthracite coal, and lying prone before it on the floor, would work away at his lessons by the glare of the fire. . . . If he could not master the portion of the textbook assigned for the day, he would not pass it over, but continued to work at it till he understood it.'"†

The course at West Point then included mathematics, engineering, chemistry, logic, French, history, drawing, topography and fortification. The length of the course was four years and during this period there was a continual elimination of cadets who failed to reach a satisfactory standard. As for Jackson, the longer he stayed at West Point the higher he moved up in his class. The original strength of the class was 72 and Jackson passed out seventeenth, but it was commonly said by his contemporaries that in another year he would have been first. His determination to master and understand the problem-

* *Memoirs of Robert E. Lee*, by A. L. Long. 1886.
† *Stonewall Jackson*, Henderson, I., p. 15.

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presented to him in mathematics, logic, and engineering, is noteworthy. He did not take things for granted or learn formulæ by heart. There can be no doubt that it was the determination to understand these subjects which shaped and strengthened his mind.

A contemporary says: "This immense application of mind was naturally strengthened by constant exercise, and month by month, and year by year, his faculties of perception developed rapidly, until he grasped with enerring quickness the inceptive points of all ethical and mathematical problems."*

In 1847 he took part in the campaign in Mexico. In 1851 he was appointed Professor of Artillery Tactics and Natural Philosophy at the Virginia Military Institute at Lexington. He remained in this post for no less than 10 years, *i.e.* until the outbreak of the American Civil War.

The subjects for which he was specially responsible were optics, mechanics, and astronomy. He was not a very successful instructor in these subjects or in mathematics. Although "a thorough master of his subject he lacked altogether the power of aiding others to master it, . . ." writes Henderson. "To the brighter intellects in his class he communicated accurate scholarship; and although the majority lagged far behind, the thoroughness of his mental drill was most useful, to himself perhaps even more than to the cadets."*

During the Civil War this thoroughness was seen in the completeness with which he studied each situation. He left nothing to chance. He dealt in fact with a situation as with a problem and intended his mind upon the various possible solutions.

In any summary of the conditions which formed and developed Jackson's mind it is impossible to avoid laying stress on his struggles and studies for four years at West Point and his ten years' professorship at Lexington in which mathematics had so large a part.

We have now examined the acquirements and temperaments of the most eminent commanders of modern times. It is evident that the further back we go in history the less influence will science be found to have, and, in fact, in the middle and dark ages organized knowledge hardly existed. We should find a closer parallel to modern conditions in classical times, and perhaps something might be gathered from the career of Cæsar, who certainly had scientific inclinations; but it is more reasonable to confine the enquiry to modern men and modern conditions.

What then may be fairly deduced from a consideration of the lives of these seven great men, Frederick, Washington, Napoleon, Wellington, Moltke, Lee, and Jackson?

* *Stonewall Jackson*, Henderson, I., p. 15.

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First, one conclusion stands out clearly. Not one of these commanders had the least inclination or aptitude for classical or grammatical studies.

Next we find that a pronounced taste for modern literature was the endowment of Frederick but of none of the others. Then it may be noted that a fondness for music was the characteristic of Frederick, Wellington and Moltke.

But the most impressive positive fact is that Washington, Napoleon, Moltke, Lee, and Jackson, and to a small degree Wellington, were all men who evinced, to a greater or less extent, an aptitude for mathematical studies and calculations. We have indeed arrived at a somewhat similar conclusion to that expressed in celebrated words three hundred years ago :—

"*As tennis is a game of no use in itself, but of great use in respect it maketh a quick eye, and a body ready to put itself into all postures; so in the mathematics, that use which is collateral and intervenient is no less worthy than that which is principal and intended.*"*

* Bacon. *Advancement of Learning.*

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RECENT DEVELOPMENTS IN TELEGRAPHY AND TELEPHONY.

By MAJOR W. A. J. O'MEARA, C.M.G., M.INST.C.E., LATE R.E.

ABOUT 12 months ago I was privileged to visit the United States and Canada, to study recent developments in engineering practice in telegraph and telephone matters on behalf of the British Post Office, and an account of the most up-to-date systems inspected, together with a brief summary of the conclusions I formed, may be of assistance to brother officers responsible in one way or another for the safe and expeditious transmission of verbal and written communications.

TELEGRAPHS.

The use of the Morse code for commercial telegraphy is gradually being supplemented and even superseded by typewriting systems, and, since the elimination of the human factor tends to promote accuracy, those responsible for the introduction of typewriting systems in the field will wish to be kept informed of the development and possibilities of such systems.

It has not been our practice in the past to look to America for guidance in telegraph methods, but in connection with my other investigations I examined carefully the methods of handling traffic and the organization of the Western Union Telegraph Company and the Postal Cable Telegraph Company. Most of the circuits of these companies are equipped with sounders, and current is usually supplied direct from the lighting mains or from motor generators run from these mains. I was informed that the Edison Lighting Company has organized the supply so thoroughly that a breakdown is practically impossible; in the event of one service of supply failing another service is available, the mains to the office traversing an alternative route. As a result, the telegraph companies named have not provided installations of accumulators, and the use of batteries for telegraph purposes is rapidly declining. Typewriters are largely used for typing messages direct from the Morse sounder, and although up to the present the results obtained by this method have not been encouraging in this country, I cannot help thinking that we must look in this direction for any improvement in the handling of telegraph traffic.

An ingenious device is the spool on which punched and received

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tape is wound to facilitate handling. Punched tape is wound on a spool as it is punched up, and then unwound by being passed through the transmitters, and received tape is wound on a spool attached to the receiver and is unwound in the process of typewriting or transcribing the messages for delivery.

Telegraph recording apparatus is extensively used in America, primarily, no doubt, on account of the penalty attached to the commission of errors in the transmission of messages, but there is only a small field for its use in this country.

There are many types of printing telegraph machines in use in the States but there are few which have not already been examined by British Post Office Engineers. Among the systems I inspected I may mention the Rowland, Barclay, Telepost and Ashley.

The Rowland system (Appendix I.) appeared to be making some headway in the American telegraph world at the commencement of my visit, but I found later that the Postal Telegraph Company considered the system was not sufficiently reliable, and after a trial of 2½ years they discontinued its use. This company is now experimenting with the Wright system, and although it is in an experimental stage I understand that satisfactory results are being obtained on a circuit between New York and Washington.

The Western Union Telegraph Company employ the Barclay system to a large extent (Appendix II. and *Fig.* 1) and so far as I could ascertain a satisfactory service was being afforded. Mr. Barclay was, until quite recently, Assistant General Manager of the Western Union Telegraph Company and he informed me that a test had been made on a New York-Chicago circuit 1,000 miles in length, when, by means of duplex working, 1,919 messages were sent from New York to Chicago during a period of 9 hours 15 minutes, and 814 messages were sent at the same time from Chicago to New York during a period of 8 hours 25 minutes. The test was made under ordinary working conditions, the messages were of average length, and the staff at each end of the duplex circuit consisted of one printer clerk, one transmitter clerk, and two punchers. The system is complicated as all machine telegraph apparatus must be, but no claim is made that it is a high speed system, and it certainly appears to be well adapted for dealing with domestic and business messages under ordinary working conditions.

I endeavoured to obtain reliable information concerning the Dean system, but without success. Inspection of the typed characters produced by this apparatus did not create a very favourable impression in my mind as to the suitability of the system for public messages in this country.

The Telepost system is very similar to the Wheatstone so far as the transmitting apparatus is concerned, and the receiving apparatus is on the principle of the Bain chemical recorder. It is claimed that

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higher speeds can be attained with the Telepost than with the Wheatstone on underground circuits.

I also inspected the Ashley fast speed system which is in process of development, but it was necessary for me to give an undertaking not to describe the apparatus as it had not been patented. It is divulging no secret to say that the system is very simple, the received signals being recorded on chemically prepared tape as in the case of the Telepost.

Radio-Telegraphy and Radio-Telephony.

My efforts to obtain information of new developments in radio-telegraphy were largely unavailing. I met Professor Fessenden in New York and visited his station at Brant Rock, but unfortunately owing to the Nicaraguan imbroglio all the operators had been withdrawn from the station. I was however afforded an opportunity of judging the possibilities of radio-telephony in a telephone conversation over a distance equivalent to 10 miles in the neighbourhood of Brant Rock, at the time the circuit was not altogether clear of disturbance and I understand that "atmospherics" constitute the chief difficulty in the progress of the art. Professor Fessenden claims to be able to eliminate the interference due to atmospherics, but responsible engineers have grave doubts as to the efficacy, under severe conditions, of the arrangement Professor Fessenden has designed. I met one engineer who informed me that he has frequently listened to a radio-telephonic conversation between Brant Rock and New York, a distance of 400 miles, but he stated that at times the atmospheric conditions rendered speech by this means quite out the question.

TELEPHONES.

The telephone situation has been rapidly developing in late years and is being complicated by the advent of automanual and automatic systems, which, as in the case of the telegraphs, are designed to dispense with skilled human agency as much as possible. As the names imply, the difference between the systems lies in the degree in which it is possible to eliminate the operator, and although the merits and demerits of the systems will be discussed later, I may state at once that, in the present state of development, the automanual system is to be preferred to the full automatic in all important commercial and industrial centres where a number of large local telephone exchanges are required to provide the public requirements.

Apart from the development of the automatic system, there are few features in the telephone situation of interest to readers of this *Journal*. During my visit I discussed very fully questions relating to the loading of aerial and underground lines, repeaters, and the location of trunk exchanges, but perhaps the most interesting development in manual telephony is the ancillary jack which provides for calls

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appearing at two or more positions on the switchboard, instead of at one position only as hitherto, thus facilitating team working.

The American engineers fully realize that, in connection with the long-distance service, it is not only the quality of the telephone service from the point of view of distinctness of speech which is an important consideration with the public, but also its availability at the moment it is required. The second of these requirements can certainly be met by the provision of a sufficient number of circuits in every case, but commercial considerations demand that the whole of the plant installed shall provide an adequate revenue to pay all expenses and to earn a profit. This clearly points to the necessity of effecting some compromise between an instantaneous service, and a service involving unreasonable delays in providing the use of lines. The subject appears to have been approached in a very commendable spirit by both the telephone companies and the public. The provision of trunk circuits is based on the assumption that the public will tolerate a longer delay in connection with places very distant from one another, than in the case of places close together, whilst, on the other hand, it is admitted that in certain cases an almost instantaneous service may justly be demanded. In order to guide the administration in the provision of additional circuits between important centres, schedules have been prepared laying down the F.S. (file and start) time for the various circuits. In other words the F.S. time is the maximum delay which it is expected that the public will, as a rule, submit to, or, in scientific terms, it is the "modulus of elasticity of the patience of the public." Should delays habitually exceed the scheduled times, the question of the provision of additional circuits is at once taken in hand by the engineers. A study of this nature led to the provision of an underground cable between New York and Philadelphia, and the number of circuits provided is such that an almost instantaneous service between these centres is now being given.

The financial considerations involved in the loading of aerial and underground lines are so great, as to call for the most thorough investigation of the results obtained in America, and the methods adopted in that country. In 1908 the British Post Office conducted an exhaustive series of experiments on underground loading, and it may be useful at this stage to recall the principal conclusions arrived at in order to clear the ground for the consideration of the further points embodied in American practice.

The conclusions were :—

(1). That in the best conditions the loading of underground circuits permits the range of speech on a given cable being increased 3·7 times, that is to say, if speech could be conducted on a given cable for 100 miles at present, then, by judicious loading, the same cable could be utilized for speaking over a length of 370 miles.

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(2). That the cost of providing and fixing the coils is very much less than the expense of providing a cable of such an increased gauge as would improve speech to the same extent as loading coils.

(3). That the loaded circuits require less duct space as a smaller gauge of wire suffices.

(4). That there is every prospect of satisfactorily maintaining loaded circuits if the best iron core coils are used.

The additional information now furnished as to American practice, and the results obtained in that country may be briefly classified under the following heads :—

(i.). Information as to the transmission efficiency of overhead loaded circuits in America, as compared with aerial unloaded circuits of the same gauge.

(ii.). The use of terminal transformers to reduce terminal losses, and the method of signalling on various types of junction circuits in which terminal transformers are used.

(iii.). Detailed information as to fitting loading coils, and the lightning protectors necessary for their protection upon poles.

(iv.). The method of fixing loading coil cases in underground manholes.

The conclusions to be drawn from a study of American practice are :—

(i.). The increase in transmission efficiency obtained by loading overhead lines is not relatively as great as in the case of loading underground circuits.

(ii.). The advantages of aerial line loading, as indicated by American experience, are so great (resulting in a saving of $2\frac{3}{4}$ cwts. per mile per wire) *i.e.* increasing the efficiency of 100 lbs. copper to that of 260 lbs. copper, that trial of this type of loading is very desirable. The only element of doubt as to success in this country is the humidity of the climate. It is stated that an insulation of 2 or 3 megohms per mile is necessary for the proper working of aerial loaded circuits, but it is believed that experience has shown that this can be obtained in England. It would appear that the best results can be obtained by the loading of wires of the smaller gauges, with the available type of loading coil. It is further very important that a lightning protector should be placed upon the poles for the protection of every loading coil. Difficulty has been experienced in America in obtaining a satisfactory protector, but it is stated that one has now been designed.

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(iii.). The use of terminal transformers, although beneficial when very short terminal circuits are connected to loaded circuits, is not necessary when these circuits are of a moderate length, and as great complexity is entailed by the use of the transformers, the conclusion in this country is that they can with advantage be dispensed with.

(iv.). The advantage of placing heavy coil cases at the top of poles is attended by such obvious disadvantages that I consider it should only be resorted to when the advantages gained as regards efficiency are considerable. An examination of the problem however, shows that for a 100-lb. circuit loaded for 600 miles the loss need not exceed 1 mile of standard cable, and it is thought that this loss is preferable to the placing of the coils upon the poles.

The telephone repeater is still largely in an experimental stage, but it is used to a considerable extent on some of the longer lines in America. Owing to its inherent physical characteristics the repeater has, at present, very decided limitations. It cannot be used on loaded lines; it introduces a certain amount of distortion, and it is particularly susceptible to conditions of line balance. A sample repeater under test was found to give such unreliable results and to involve such difficulty in eliminating "singing," that it is clear considerable additional work has to be done before it can be installed to general specification for commercial use.

Automatic Telephones.

I devoted considerable attention to the study of the automatic telephone situation in America, and inspected five different types of switch equipment designed to provide automatic and semi-automatic telephone service. Three of these equipments were seen in actual operation, a fourth as an exhibit, and the fifth in process of construction. I visited one of the pioneer installations of the "Strowger" equipment at Grand Rapids, and the latest types of this system at Omaha, Columbus (Ohio), San Francisco, Los Angeles, and elsewhere. The Lorimer system I saw in operation at Peterborough and Brantford; and the North Automanual type in operation at Ashtabula (Ohio). The American Automatic Company had an exhibit of their equipment at Chicago, on the occasion of the annual convention of the Independent Companies, which I was enabled to visit, and the Western Electric Company very kindly afforded me facilities for inspecting the switchboard, which is being built in order that the company may fully study the technical and economic aspects of semi-automatic switchboards for use in multi-office areas.

The desire to operate telephone exchanges by means of automatic equipment dates back almost to the first days of intercommunicating telephone circuits. The growth in recent times has been due largely

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to the enterprise of a manufacturing company—the Automatic Electric Company of Chicago—which has succeeded in capturing the Independent Companies, and there seems to be little doubt that the aspect of novelty has been seized upon as a means of competition with the older forms of switching equipment.

Advantages and Disadvantages of Automatic System.

The advantages claimed for the automatic system may be summed up as follows :—

(*a*). The elimination of human agency in switching.
(*b*). The certainty of connection within a given time.
(*c*). The rapidity of disconnection when the calling subscriber replaces his receiver, thus releasing costly junctions and enabling those circuits to carry a heavier load.
(*d*). Uninterrupted all night service without additional expense.
(*e*). Saving in operator's wages, buildings, conduits and cables.

On the other hand opponents of the system point out that the following are amongst the more serious disadvantages of the automatic type of plant :—

(*a*). Complexity of apparatus.
(*b*). Heavy capital expenditure in exchange plant.
(*c*). Increased maintenance charges.
(*d*). Inadequate means of registering the number and class of calls and limitation to a uniform rate of charge.
(*e*). Impracticability of working arrangements for a series of junction circuits exceeding two in number.
(*f*). The failure of a single unit may cut off 100 subscribers.
(*g*). It is possible for a mischievous person to send a false call and "engage" the line of some subscriber against whom he bears malice or whose interests clash with his.
(*h*). The calling device cannot be operated in the dark.

It is claimed that in the manual system the operator exercises continual supervision of the lines under her control, and that this supervision is not obtainable in the automatic system ; but this statement is hardly correct, as the switch attendants are continually patrolling the exchange, and if they notice (as they are able to do) that a particular line is engaged for an inordinate length of time, it is their duty to investigate the matter. I think that automatic exchanges will work best in communities where the interests involved are not of a keen competitive order ; requirements of a special nature are difficult to provide on an automatic switch, and for all preferential services and trunk working operators will continue to be necessary. No means have yet been devised for dealing with calls for which a different rate of payment is demanded, and this is a serious defect in the case of large areas in which a differential rate at present prevails.

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The abuse of the system by swindlers and evil-disposed persons is, I understand, mitigated by the employment of detectives by the companies, and it is claimed that little or no trouble of this kind is now experienced. One other disadvantage of the automatic system, which is not however very serious, is that if a subscriber accidentally depresses the receiver hook during his conversation he is immediately "cut off" from his correspondent.

There are many features common to the three full automatic systems which may be eliminated in comparing them with each other, such as for example the advantages and disadvantages of automatic and manual in all its aspects, which I have already dealt with. The general features of the exchanges are such as now appear to be applied by all automatic telephone companies, that is to say, all the systems give full common battery facilities, the exchange apparatus works on the step-by-step principle, and the various switches are designed on a percentage basis for connecting simultaneously a predetermined percentage of subscribers at one and the same time. At the subscribers' stations the principal features of full automatic systems are also similar. The calling subscriber must always select the called subscriber and either rotate a handle and dial (American Automatic system), turn a dial (Strowger), or move fixed levers and wind up his apparatus (Lorimer) in order to put the automatic selective apparatus into motion. There is still some doubt in the minds of the engineers responsible for the installation of the Strowger equipment, as to whether the so-called three-wire system—*i.e.* one using "earth" in connection with the calling device—or the so-called two-wire system in which no such "earth" connection is used, is the more satisfactory one in actual practice. Another feature which divides the automatic equipments into two groups is that the Strowger and American Automatic systems are wholly operated from the sub-stations, but in the case of the Lorimer the calls are set up by the positive action of the selecting devices at the exchanges, on the arrival of a preliminary signalling current; the number required having been first completely set up at the subscriber's instrument.

The Lorimer subscribers' apparatus presents the most convenient arrangement for calling, inasmuch as the completed subscribers' number is continually on view until the next number is set up; this is not the case in the other two systems. The apparatus at the exchange is of a very robust construction, and the contacts are made by the positive action of a machine which is power driven. The parts of the mechanism are therefore more durable and the life of the plant should be longer. Any sparking at electrical contacts is arranged in this system to take place at the exchange and not in the subscribers' apparatus, and the motion of the machine parts consists in the uniform rotation of brushes over cylinders—there is no stepping

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up vertically and horizontally. The disadvantages of the system include the cost of power to drive the mechanical parts, which must be kept continuously rotating, but the advantage gained by the solidity of the parts will no doubt materially reduce the depreciation factor. The step-by-step movements appear to be more numerous than those in other systems, and the continuously rotating machinery would necessitate much more attendance at district exchanges than would be required in the absence of it. Technical details of the system are given in Appendix III.

The Strowger system (Appendix IV.) has been more extensively used than any other, and there is the advantage that greater experience has been gained of the operation of the system, which has led to a more fully developed method of working junction, party, lines, and message rate circuits, etc., than in any other system. No power machinery is required at the exchange to drive the selective machinery as is the case with the Lorimer, and the equipment appears to require less space than the Lorimer apparatus. The disadvantages are that in order that the electric parts in the exchange may be driven with sufficient speed by impulses over the subscribers' lines, they are comparatively light and not so durable as compared with the Lorimer system, but the first cost should consequently be low. The motions of the selector switches involve vertical and horizontal movements which do not appear to be so simple as the simple rotary movements in other systems, and it is thought that some sparking takes place in the subscribers' apparatus. The rotation of the disc on the subscribers' apparatus is not so convenient as the arrangement in the Lorimer system, since the completed number of the called subscribers is never on view. The system is so delicate from the electrical point of view that great care must be exercised to prevent any but very slight variations in the line voltages.

In the American Automatic Company's system (Appendix V.) the various switches and selectors appear to be of simple uniform design, the wipers or brushes only moving over a semicircle in each case, without vertical movement. There is no continuously rotating machinery at the exchange for selective purposes, and the apparatus appears to be compact. In this equipment the relays and other parts liable to derangement, have been mounted on plates which can be readily removed and replaced by others. From the maintenance point of view such an arrangement presents very considerable advantages. The disadvantages associated with the system are that the movements on the dial of the subscribers' apparatus are not so convenient as the device in connection with the Lorimer system, for the reason that the completed number of the called subscriber is never on view, but there is one feature in the dial which appears to make it more convenient than the Strowger dial, *i.e.*, one operation of the dial is alone necessary to call numbers up to 50, and four digit

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numbers can be set up by two motions only of the dial where numbers under 5,000 have to be dealt with. From a mechanical point of view this type of equipment has an advantage over the Strowger, since only a rotary movement is necessary in the selectors, and, in consequence, the moving parts are more substantial and will probably prove to have a longer life.

Automanual *versus* Automatic Systems.

There is no doubt there are considerable advantages attached to a system in which the subscribers' apparatus can be made as simple as possible, and in which the operations to be effected at the sub-station require the minimum amount of intelligence. In the automanual system (Appendix VI.) the subscriber is relieved of the manipulation of the selective device upon his telephone ; all the automatic apparatus is concentrated in the exchange and its maintenance simplified in consequence. Further, the elimination of the subscriber's circuit from the automatic arrangement will tend to the better working of the automatic machinery, as impulses have not to be transmitted over the lines, and any leakage faults upon them would not have such serious consequences. As calls are automatically distributed to the disengaged operators and manipulated at the exchange, there will be possibilities of utilizing the operators to the fullest advantage, and this will give more elasticity to the service as regards the operation of junction circuits, trunk circuits, party lines, metered services, etc., than would be possible in a full manual system. The operators, also, being continually employed in the manipulation of the numbers, will become expert and a rapid service will result. The expertness of the operators as compared with that of the subscribers cannot fail to reduce very appreciably the liability to errors in operating the automatic selective devices, and the conditions prevailing at the exchange allow of the most suitable devices being designed for operating the switches. The subscribers' apparatus will be cheaper and simpler to maintain when the automatic selective device is removed to the exchange, and the absence of complexity at the sub-station office will be an inducement to all to become subscribers whose time is of value, and who do not care to be troubled with a selective arrangement.

The disadvantages include the increase in the cost of operating and of exchange buildings as compared with an automatic system. The latter is due to the increased space required by operators' positions, retiring rooms, etc. The rapidity of the service will be dependent upon the speed of answering of the operator, and to those subscribers who find the elimination of the operator an advantage, the system will be open to objection.

In brief, an automanual system will be more efficient, more rapid, and more elastic, particularly in urban districts, than an automatic system, but it will be more costly in operating expenses.

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Keith Line Switch.

In any telephone system the cost of the wire, cable, and conduit, is always the largest factor, and it not infrequently represents two-thirds of the entire first cost of the system, depending of course not only upon the number of lines, but the density of the plant as determined by the location of the business centre, the nature of the soil, and the obstructions encountered. In the manual system if the number of subscribers in an outlying district is insufficient to justify the erection of a small exchange and the provision of staff and superintendence, the district can only be served by running lines from the main exchange. The automatic companies in an endeavour to overcome this difficulty have provided small sub-stations, located so that every subscriber will be within reasonable distance of one of them. Junctions are run from the sub-stations to the exchange. It is claimed that these sub-stations or Keith units (*Fig.* 2) can be located in cellars, or outbuildings, or even in manholes in the street, and can be run without staff. Maintenance visits by the linemen would, of course, be necessary, but at infrequent intervals. I doubt, however, if any substantial economy is effected if we take into consideration the cost of housing the plant (however small this may prove to be), and of the time occupied in maintenance visits. The "units" are to some extent the weak parts of the system, and as they must be located some distance from the exchange the time occupied in maintenance visits cannot be inappreciable.

Conclusion.

The greatest care has been taken by the automatic telephone companies in selecting and training men for the maintenance of the equipment, and I am of opinion that much of the success of the system is due to this fact. The chief engineer of one company informed me that it takes from three to four years to train a switch attendant, and even then the man must be fairly intelligent before the training commences. The automatic equipments inspected were all working very smoothly, the standard of maintenance being excellent, and I cannot lay too much stress on the necessity for the employment of highly-trained "troublemen," or linemen, in connection with the maintenance of the automatic system. Military requirements necessarily differ from commercial requirements, but if the automatic systems can be made thoroughly reliable the advantages accruing from the elimination of the operator without any increase in the transport required for the engineering plant should form an inducement to the authorities to adopt the system for military purposes.

It is necessary to emphasize the point that the mechanics required to look after the automanual and automatic switch equipments must be very highly-trained men, but the number of mechanics need be no greater than is at present employed on the maintenance of magneto exchanges.

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APPENDIX I.

THE ROWLAND TELEGRAPH SYSTEM.

The Rowland is a duplex multiplex printing system, and is based on the principle that the carrying capacity of a wire is far in excess of the operator's ability to send. Messages are transmitted in both directions over a single wire by synchronizing the apparatus at each end and giving to each of four operators the use of the wire for a short period. The dominating feature of the Rowland System is that a current is always on the line and the signals are made by reversal of certain impulses. Thus it is essentially different from those systems in which no current passes along the wire except at the instant when the message is to be signalled. The system can be duplexed so as to provide four channels in each direction, or eight in all. At the sending end a transmitter, similar to the keyboard of a typewriter, is fitted on each channel. The actual signalling depends on special combinations of the typewriting keys, each of which has 11 contacts, so that it is possible to form 35 different signals The depression of a key reverses two of the 11 impulses sent out by the alternator, and this reversal of current causes the relays at the distant end to operate the printing receiver which is under the absolute control of the sending operator. A record of the signals is also made at the sending end on a tape printer.

At the receiving end the type wheel of the printing mechanism is kept revolving in synchronism with the incoming reversal, a bank of distributing relays being utilized to select the required letter according to the signals received. The printing of the messages is done automatically in ordinary type in page or any desired form.

In order to secure perfect synchronous movement between the transmitting and receiving apparatus, the speed of the latter is varied by means of a rheostat until a musical sound of a definite pitch is obtained in the telephone used as a synchronizing detector. The inherent defect of the P.O. Multiplex System is thereby avoided.

It is claimed for this system that a speed of 35 words per minute per operator can be obtained, so that with duplex arrangements a speed of 280 words is possible, with the advantage that the messages are printed ready for delivery.

Viewed from the economic aspect, the merits of the Rowland over existing types of Morse systems used in the British Post Office are :—

1. No time occupied in writing up messages.
2. Employment of typists instead of expert telegraphists.
3. Increased output of work.

On the other hand, the Rowland apparatus is very complicated, and its use would probably be limited to busy centres.

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APPENDIX II.

THE BARCLAY PRINTING TELEGRAPH SYSTEM.

The Barclay Telegraph System is essentially a Wheatstone Automatic Duplex System with the addition of a printing apparatus in the local circuit. This apparatus consists of:—

1. A keyboard perforator, so arranged that the depression of a key brings into play various combinations of levers to form a particular letter. The action is purely mechanical, except that a 110-volt. D.C. motor is employed to expedite the mechanical operations.
2. The transmitter differs from the P.O. Wheatstone transmitter in one or two details, chiefly the use of dynamos for sending the currents to line; arrangements are also made to keep the driving mechanism in constant motion during certain prescribed hours of the day, a 110-volt motor being employed for the purpose. The operation of "winding up" which detracts from the value of the Wheatstone System is entirely eliminated.
3. A polarized relay is also used at each end of the line and is identical with the P.O. standard relay with the exception that the permanent magnet is replaced by a third coil of 100 ohms resistance through which a local current of 50 milliampères is always flowing to increase the sensitiveness of the relay.
4. The printer is really an electrically controlled typewriting machine adapted to telegraphic purposes. In place of the usual finger keys, a series of electro-magnets are utilized to manipulate the mechanism by which the type wheel is rotated and brought into position ready for printing.

Messages for transmission are first treated by an operator at the keyboard perforator, producing a paper tape with perforations representing the message in the Barclay code. This tape is passed through the transmitter which sends to line the desired long and short currents. At the other end of the line the various letters are formed by different combinations of three positive and three negative currents. These currents actuate the polarized relay which in turn actuates a bank of distributing relays. The latter are utilized for the purpose of setting up certain predetermined combinations, which rotate the type wheel of the printer into any selected letter position, and at the same time bring it into contact with the message form upon which the letter is printed. After the selection and printing of a letter, the distributing relays are restored to their normal position by a local current.

The maximum speed of Barclay apparatus is 100 words per minute under simplex conditions.

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Compared with the Wheatstone Automatic System, the Barclay has the following advantages:—

1. No time occupied in transcribing messages.
2. Any particular letter is formed on the keyboard perforator by a single depression of the key lever, compared with two to five depressions on the Wheatstone perforator.
3. Multiple copies of messages can be obtained.

On the other hand the keyboard perforator of the Barclay System is complicated and requires a heavy current (3·4 ampères at 105 volts = 357 watts).

APPENDIX III.

THE LORIMER SYSTEM OF AUTOMATIC TELEPHONY.

In this system the subscribers in the main exchange are divided into entirely separate groups of 100, and this permits of future extensions with a minimum of complexity.

The apparatus is designed to affect the switching operations for a percentage only of the subscribers in the same way that pegs and cords provide for putting through only a percentage of the circuits connected in an ordinary exchange.

The apparatus for each 100 subscribers is divided into two parts (1) a sectional division and (2) as many percentage divisions as there would be pairs of pegs and cords in a manual exchange.

The apparatus consists generally of cylindrical switches with tags inside, and brushes revolve inside these cylinders and make contact with the tags as required. In one case (the Decimal Indicator Apparatus) the brushes are stationary and the other part revolves.

One hundred subscribers are connected to the decimal indicator of the sectional division, each circuit being terminated on separate contacts but one indicator sufficing for the whole. The percentage division has five separate cylindrical switches with auxiliary ones for advancing the switching operations step by step. The subscribers' apparatus contains a disc divided into four quadrants with contacts corresponding to units, tens, hundreds, and thousands and with contact brushes driven by clockwork.

To effect a call the brushes are placed on the number of the required subscriber; this closes a circuit to the exchanges, actuates an electromagnet, and the revolving apparatus on the sectional division stops, a free percentage division is brought into use and the calling circuit by the same movement is connected to it. Then step by step the units and tens of the called subscriber are joined up by the switches and the interconnector finds a free percentage division in whatever hundred the called subscriber may be found. The various switches are actuated by current impulses sent over the subscriber's circuit due to the brushes on the subscriber's apparatus being driven by clockwork over metallic contact

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points. These current impulses drive the exchange switches through the agency of electro-magnets. The number of impulses is determined by the position of the brush on the number of the called subscriber.

When the called subscriber's line is joined up the calling subscriber presses a button and rings him up. The clearing signal is given when the receiver is hung up.

The system is common battery for speaking and signalling. The moving brushes are actuated by machinery which must be in continuous rotation day and night. Heavy currents are required. The mechanism is more complex than others and the expense of maintenance would probably be high.

Spare apparatus would be necessary as the consequence of the stoppage of a sectional division with 100 subscribers would be serious.

APPENDIX IV.

STROWGER SYSTEM OF AUTOMATIC TELEPHONY.

A typical Strowger Automatic System consists essentially of:—

(*a*). The subscriber's signalling apparatus.
(*b*). Step-by-step switching apparatus at the exchange for passing on the calls.

The subscriber operates the central exchange mechanism by the manipulation of a dial on the front of his telephone, the rotation of which actuates the switches at the central exchange by means of current impulses sent along the line and causes the switches to select automatically the telephone of the subscriber with whom the caller desires connection.

The exchange equipment is divided into units of 100 lines so that the exchange equipment can be augmented on the unit system. The number of selectors used, however, is governed by the size of the exchange.

The essential exchange apparatus consists of:—

(*a*). The line and master switch.
(*b*). First and second selectors.
(*c*). A connector.

Each subscriber's circuit terminates on a line switch in connection with a master switch (which controls a group of line switches). The master switch performs the function of an operator in transferring a call from the 100 group of lines in which it originates to a disengaged line in a group of 10 circuits which correspond to the pegs and cords of a manual exchange. The 10 circuits terminate on a "first selector." This piece of apparatus controls the group of "thousands" circuits. The selector switching apparatus consists of rows of tags—placed vertically one above another—and a wiper or contact brush which, by means of impulses sent over the subscriber's line and through the agency of an electro-magnet, step up the wiper on a vertical rod to the row in which the required thousand is found, the wiper then moves horizontally and automatically

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along the line of tags till a disengaged circuit is found. By this means the calling line springs are connected to a "second selector" which continues the connection to the hundreds group governed by impulses from the subscriber's line. The second selector is similar to the first and joins up the line to a further similar switch called "the connector," which finally completes the connection to the called subscriber's line. The subscriber hangs up his receiver on the completion of the call and earths both lines, thus causing the release of the clearing mechanism by means of relays acting on the various dog clutches. The subscriber can clear at any time by replacing the receiver.

APPENDIX V.

AMERICAN AUTOMATIC TELEPHONE COMPANY'S EXCHANGE SYSTEM.

This is a common battery 2-wire system, and it consists essentially of:—

(*a*). A subscriber's signalling device.
(*b*). A finder
(*c*). First and second selectors } At the exchange.
(*d*). The connector

The subscribers' apparatus in addition to the ordinary C.B. speaking device, contains clockwork and a dial with letters and numbers around its circumference. Instead of merely a number, a combination of letters and numbers may be used, as, for example, "DC 12." The dial has 50 holes around its circumference, with letters and a number opposite each hole.

To call the subscriber DC 12, a handle, forming a radius of the dial, is turned until it stands opposite the letter D, and at this point the handle is pressed down, thereby pressing a pin into a hole. The dial is then turned round clockwise by the handle, and allowed to rotate back by its own spring tension. The operation just described is repeated for "C" and "12." Each of the rotations of the handle sends a number of impulses over the line, the number of these impulses being regulated by the letters and figures operate on the dial.

In the exchange the subscribers' circuits are divided into groups of 50 and, as is usual in automatic systems, the exchange can be built up in independent units without costly alterations to the multiple.

The 50 grouped subscribers terminate on "finder" switches. A finder switch has 50 subscribers' circuits terminating on tags arranged in a semicircle with a "wiper" or "brush" which forms a radius of the semicircle, and which is stepped round the contacts by a ratchet wheel actuated by the armature of an electro-magnet known as the motor magnet, this is in turn controlled by a line relay worked by impulses from the subscribers' circuits. Each group of 50 subscribers' circuits in a 5,000 exchange has the possibility of using any one of six finders,

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and these finders correspond to the pegs and cords in an ordinary exchange. It will be seen, therefore, that provision is made for the connection of 12 per cent. of the subscribers at the same time.

The wipers or brushes are each in connection with a "first selector" one such item being provided in connection with each finder, and it joins up the subscribers to the "thousands" group of circuits by impulses sent *viâ* the finder to the controlling magnet of the first selector which causes the wiper to step round by means of a ratchet wheel as in the case of the finder switch. If the wiper should rest on an engaged circuit contact for an instant, this contact will be found to have a potential upon it, and as a consequence a further series of impulses will be sent through the motor magnet which automatically causes the wiper to move forward until a disengaged circuit is found. The first selector through its contact springs joins the calling subscriber to a second selector which is a switch of the same construction as the finder and first selector switches, and the second selector in turn continues the connection by similar means to another switch of like construction, termed a connector, which finally joins the line to the called subscriber.

When it is desired to clear the circuit on completion of a conversation, the receiver is hung up and a relay operated which releases the various clutches and allows the different switches to fall back in their normal position in readiness for another call.

APPENDIX VI.

THE CLEMENT AUTOMANUAL SYSTEM.

An installation comprises :—

(*a*). Standard common battery apparatus at the subscribers' office.
(*b*). Operator's signalling table
(*c*). Selector
(*d*). Connector
} At exchange

in addition to power plant, generators, fuse and protector frames, etc.

Operation of the System.

(*a*). When the subscriber lifts his receiver, a lamp lights in front of the operator who depresses speaking key, repeats the figures to the subscriber and at the same time signals the number required.

(*b*). Each operator has sets of numbered keys, three lamp signals in connection with each set of keys, and a speaking key and a starting key common to the set. Each set of numbered keys is connected by a separate call wire to a switch which is actuated on the lifting of the subscriber's receiver. If one set of keys is engaged, the subscriber's line will be connected automatically to the next set. Three sets of keys are provided at Ashtabula.

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When the starting key is depressed, the subscriber's line is connected to the switches which complete the circuit to the required line, and the operator's call wire junction to the number keys is free for the next call.

(*c*) and (*d*). These are similar in principle to the Strowger type, and perform the same functions. The spindle however moves first in a rotary, then in a vertical direction.

The contacts are made vertically and it is considered that this ensures greater freedom from dust troubles.

Call Wires.

Two exchanges may be worked by operators at the main office. In this case, the call wire junctions to the keys for each operator are extended from the selective switch at the sub-office, to the keyboards at the main, and it is a matter of financial consideration whether it would be cheaper to extend the junction circuits and concentrate the operators. or save the cost of junction lines and provide separate staffs of operators.

The proportion of call wire junctions is low, as the time they are required for each call is very brief; the estimated proportion of call wires is less than 1 per cent. at the larger exchanges.

Junction Lines.

Separate junction circuits for the actual conversation between the subscribers are provided, and where there are several sub-exchanges the circuits may be taken by the most direct route, not necessarily through the main exchange.

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EFFECTS OF A LIGHTNING STROKE ON AN ELECTRIC LIGHT INSTALLATION.

By Capt. R. St. J. Gillespie, R.E.

The writer has lately had what he believes to be the somewhat uncommon experience of a flash of lightning directly striking the wires of the electric installation in his charge, and has thought it worth while to record the exact details of the effects, in the hope that the account may be of value or interest to other officers.

The conditions are, of course, somewhat abnormal, as it is unusual to find a large building, equipped with electric light, standing in an exposed position and yet not fitted with lightning conductors.

At the same time it may be noted that though thunderstorms are common in Chamba a stroke in the town has rarely been known, probably owing to the fact that the town is closely surrounded by high hills.

In this case, during a heavy and prolonged thunderstorm, the lightning struck the roof of the Palace, which consists of two main portions, the Khanchandi Palace and the Zenana Palace.

The Khanchandi is a two-storied edifice built in the form of a hollow square with a smaller square enclosed in one corner. It has a low pitched roof of slates, with a plank ridge covered with strips of galvanized iron. There are few chimneys and the roof has only two breaks in its continuity, viz. over the main gateway, where it is higher than the rest, and at point (E) on the accompanying plan, where there is a gable, the roof over the inner square and Banqueting Hall being a few feet lower than the rest. There are no lightning conductors on this part of the Palace, which is completely fitted with electric lights.

The Zenana Palace is a newer and much more lofty building, roofed with corrugated iron, and with several high gables. It has lightning conductors, but they have not been tested for many years though they appear to be mechanically intact. The ridges are ornamented with iron scroll work, well adapted for dissipating static charges of electricity. There is no electric light in this part of the Palace block. Nearly the whole of the upper story of the Khanchandi consists of long empty galleries with wooden ceilings, the

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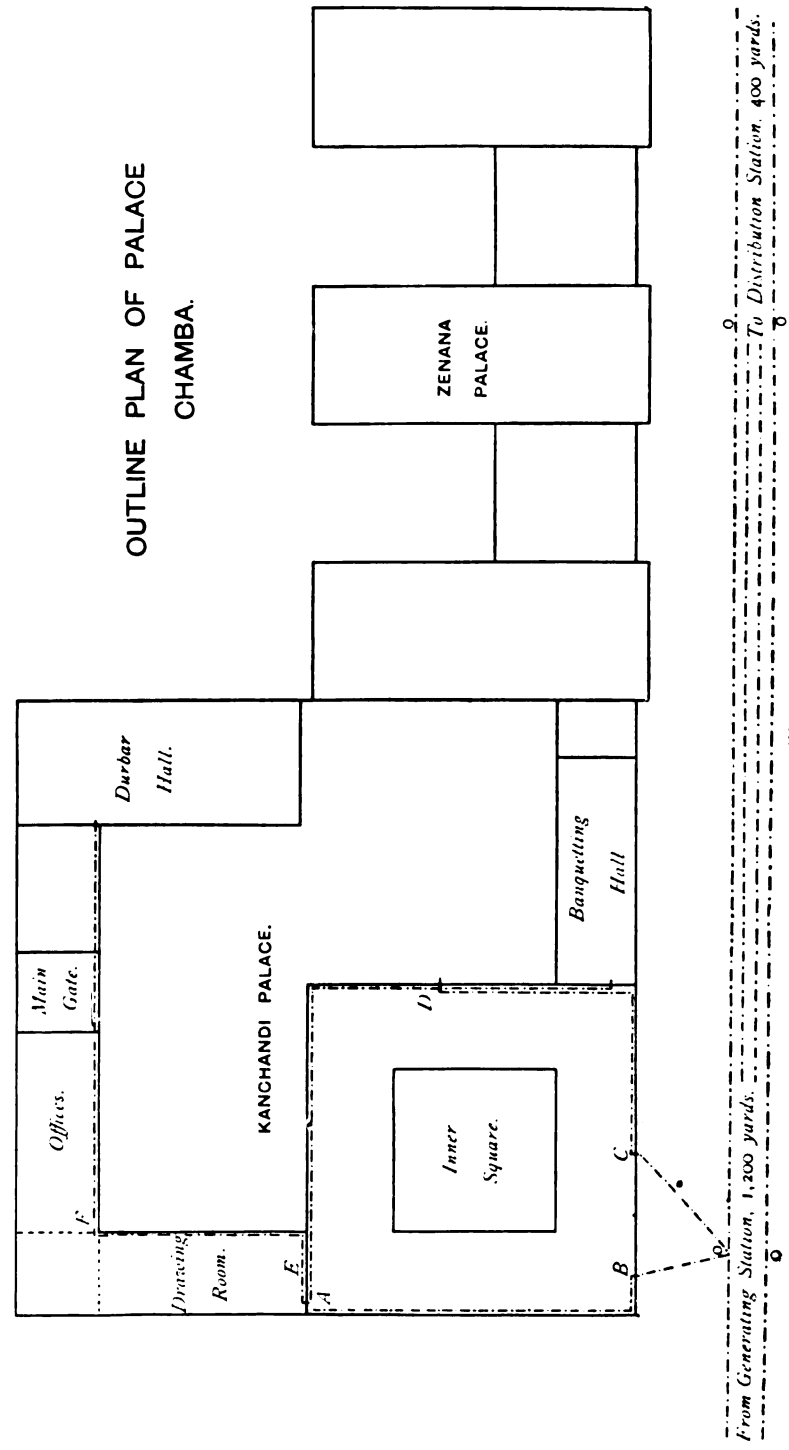

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lower floor containing State reception rooms and offices. The only part used for habitation is the lower floor of the inner square.

The Durbar Hall roof is the same height as the rest, but the Hall itself is the full height of the building inside. The main transmission lines run along the west side of the Palace being of bare copper carried on Hamilton poles. The mains for the Khanchandi enter close under the eaves at (B), where a pair of Garton lightning arresters are fitted. Inside are a pair of "Reason" type main fuzes, and from these a pair of 19/16 leads runs to the main marble switchboard at (A). This has a double-pole main knife switch from which are taken the leads for the three main circuits.

A pair of 19/16 leads pass through two large china hand-grip type fuzes, and thence along the gallery walls to the Durbar Hall, where there is a wooden switchboard with another d.p. knife switch on the mains, and a number of distributing fuze boards and tumbler switches for the fans and lights in the Hall.

A pair of 7/18 leads pass through a d.p. tumbler switch and a pair of fuze boxes on the main board, and under the floor of the gallery over the drawing room and offices to supply the latter. Another pair of 7/18 leads pass through a similar switch and fuzes, and round the gallery of the inner square to the Banquetting Hall where there is another main switch and distribution switchboard.

The Durbar and Banquetting Hall mains are in wood casing along the top of the gallery walls.

At (C) another set of leads come in from outside, through a d.p. tumbler switch and a pair of "Reason" fuzes, and then round the gallery to (D), where they cross the Banquetting Hall leads and go out to join the armoured cables which feed the flaming arcs in the courtyard. The joints to the armoured cable are high up on the wall outside. There are Garton arresters at (C) outside.

All main leads are in wooden casing except those under the flooring.

A heavy thunderstorm accompanied by steady rain began on the evening of January 24th, and continued without intermission till the morning of the 26th. About 7.30 p.m. on the 26th there was a brilliant lightning flash simultaneously with a deafening peal of thunder, and all the electric light in the town went out at the same instant. After a few minutes the lights came on again, and the state of the 50-c.p. Osram lamps in the Club at once showed that the wires had been struck somewhere. These lamps burnt with the most intense brilliancy on account of their filaments being all twisted together and half short circuited. Needless to say the brilliancy was of short duration.

Next morning, investigations showed that the lightning had struck the Khanchandi Palace somewhere above the drawing room. A

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careful examination inside and out led to the discovery of a couple of small holes in the galvanized iron ridge 6′ from the gable at (E).

The holes are irregular oblongs about 1″ × ½″ and look as if they had been burnt out by an oxygen flame, and under one of them was a black charred mark on the planking. The writer is of opinion that this is the actual point where the flash struck.

A few inches away was the second hole which was found to be exactly over the head of an 8″ iron spike evidently meant to fasten the ridge plank to the truss beneath. The carpenter who drove the spike had made a bad shot, missing the truss by a couple of inches, leaving the spike projecting into the roof space beneath. The head of the spike showed clear signs of fusion and from its lower end a discharge had evidently taken place, the point having been melted and the truss close to it having a black charred mark as if of a flame.

From the point of this spike the lightning evidently jumped a space of about 4′, taking the shortest and straightest path to the Durbar Hall leads just below the cornice of the gallery below. The cornice offered little resistance to the flash, being neatly cut through as can be seen from *Photo* 1.

A similar mark in the cornice was found at (F), and it would seem as if part of the flash had run right along the ridge, down the iron gutter, leaving a mark like that of a hammer, jumped an inch to an iron nail and thence through the cornice to the leads again. The lightning thus got clear on to the 17/18 Durbar Hall leads. The d.p. knife switch in the Hall was open, but all switches on the main board were closed.

The two large china fuzes were blown to atoms with such force as to completely wreck the marble switchboard, as may be seen from *Photo* 3.

The easiest course from this point for the discharge to take was out through the main leads at (B) and apparently the greater part went this way. The main fuzes at (B) show only slight traces of the passage of the current, but one of the arresters outside was blown to pieces, the other being, strange to say, undamaged. The fuzes to the drawing-room circuit were not blown, but those to the Banquetting Hall had gone violently, smashing the china covers to bits.

Both these pairs of fuzes had No. 12 tin and lead fuze wire in them, while the large pair had thin copper wire, No. 18 gauge. The reason for the blowing of the Banquetting Hall fuzes was soon apparent, as it was found that the lightning had broken through the insulation of both pairs of leads at the objectionable cross at (D), and had gone to ground in both directions on the arc lamp leads. The d.p. tumbler switch at (C) was open, but this made no difference as the discharge jumped from one terminal to the other by way of the brass covers, punching holes in the latter. Both lightning arresters were badly

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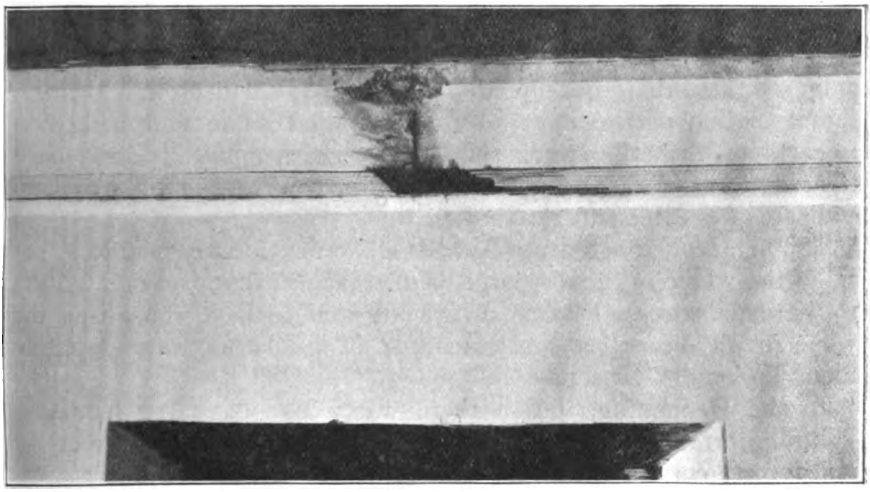
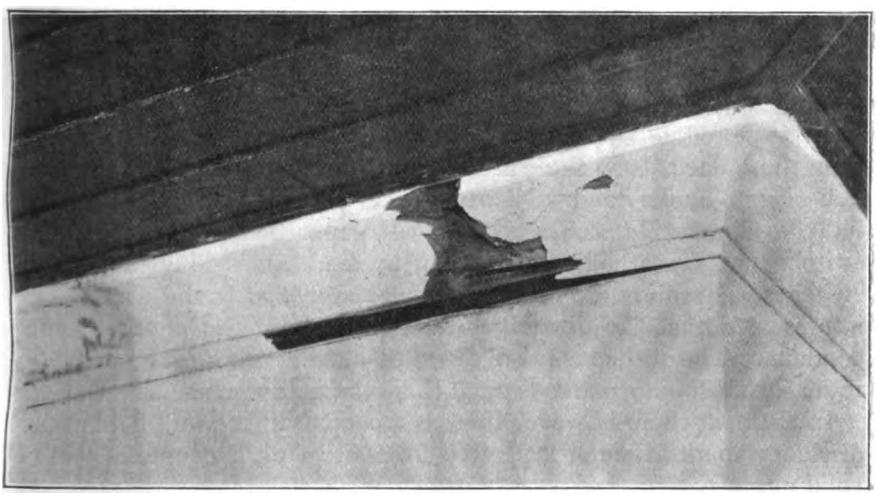
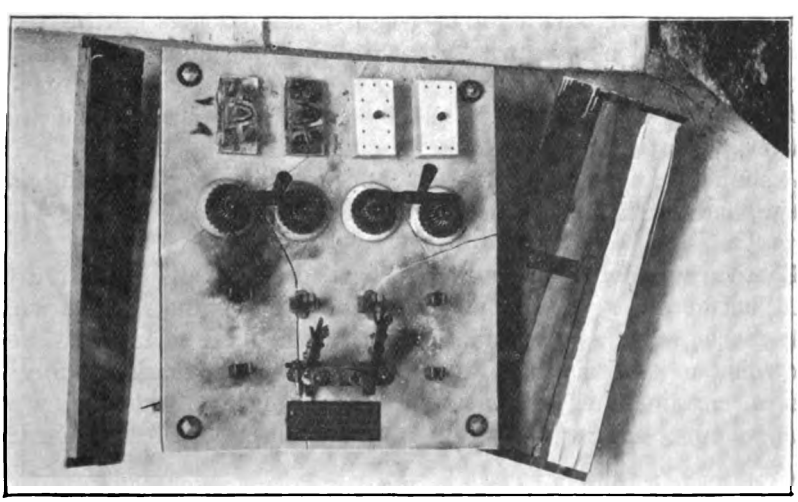


1.—Cornice Pierced by Flash at E.



2.—Cornice Pierced by Flash at F.



3.—Main Switchboard Wrecked by Flash.

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damaged. In the other direction the discharge had broken through the insulation at the joint to the armoured cable and had gone to earth on the armouring. The Palace guard appear to have been treated to a fine display of fireworks from the tops of the arc lamp standards from this part of the discharge.

The lightning arresters at (B) and (C) were evidently unable to get rid of the whole of the discharge, being taken in rear, and part got on to the main wires. Flashes of fire are said to have run along the wires in all directions, and a couple of insulators were certainly found broken.

In the Generating Station there was a fine discharge from the lightning arresters behind the switchboard, and both the overload and reverse current circuit breakers came down. The Sikh carpenter in charge was not dismayed but shut down his turbine promptly, and finding no damage done to his dynamo started up again and switched on to the mains again cautiously.

At the Distribution Station, about 400 yards from the Palace, no damage was done except to the lightning arresters, of which four or five suffered.

In the Palace itself the effects of the discharge are numerous and not easy to understand. Nearly every lamp in the drawing room had its filament broken and the wall paper below each group of switches was scratched and torn as if by mad cats. The leads to the switches in question are in iron conduit embedded in the wall, and it is presumed that the discharges took place from the ends of these conduits. The wall paper on the wall at the south-east corner of room shows similar marks though there are no switches here.

In the next room however there is a conduit in the wall behind the discharge marks though separated from them by a couple of feet of solid masonry.

The Durbar Hall has four 24-light electroliers, wired from the ceiling high above, and a lot of 3-light brass brackets on the walls, the wires to which are carried about 10′ from the floor along the top of the panelled wooden dado.

Sixty per cent. of the lamps in the electroliers went up but a much greater proportion suffered in the brackets.

It should be noted that at that time no lamps were burning anywhere, and the main switches in both Durbar and Banquetting Halls were "off."

There are numerous marks of discharges on the walls of the Durbar Hall, but here they cannot be accounted for by conduits in the walls.

It rather looks as if every piece of metal in the Hall had been electrified and had discharged to earth, many of the marks leading up to iron curtain brackets, and some to the electric brackets, while others seem to have no apparent starting point. In the Banquetting

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Hall the damage to the lamps was about the same as in the Durbar Hall, but no discharge marks were found on the walls which are covered with a heavy moulded red and gilt paper well varnished.

There are ceiling fans in all the large rooms but these were practically unaffected, one carbon brush being found broken and one wire being found out of its terminal.

After re-insulating the damaged portions of the main leads, insulation tests were taken. The Durbar Hall gave 2·5 megohms while the smaller circuits went up to 30 and 40. Altogether out of 290 lamps over 150 were spoilt.

The installation of the electric light in the bazaar and private houses has only just begun, but there are altogether eleven installations in the town besides the Palace. Four of these were fitted with Garton arresters, the remainder with home-made horn arresters of copper wire.

Of the former, two suffered no damage to lamps at all, the other two only losing one or two. A couple of arresters were damaged. Of the houses fitted with horn arresters, some lost many lamps, some a few, one lost none. It apparently depended on the condition of the horns. It was found that the monkeys, which are an unmitigated nuisance on an overhead electric supply, had knocked the horns into all sorts of shapes and the spark gaps varied from $\frac{1}{8}''$ to $2''$. The larger the gap, the greater was the damage. The conclusion arrived at is that horn arresters are just as good as the more expensive Garton type if only the monkeys can be kept off them.

It is difficult to arrive at any very definite conclusions from these effects.

According to theory, if the building had had lightning conductors it would probably have not been struck. It was struck at the most likely spot on the highest point of the most prominent and largest area of roof. A lightning conductor here would almost certainly have carried the discharge harmlessly to earth.

The electric light leads inside the building acted as an internal lightning conductor, an undesirable and expensive form, and prevented further damage to the structure, and injury to the people in the lower floor of the inner square who were quite unaffected.

Lamps were destroyed by induced currents in nearly all cases, as it made no difference if they were burning or not except in the case of the Club which is lit entirely by Osram lamps. Here no lamps were broken that were not switched on.

Distribution board fuzes were generally undamaged except in the case of those for the Durbar Hall brackets which all went. They are all of fine tin lead wire 5-ampere capacity.

The explosion of the hand-grip type fuzes on the main switch-

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board, while the main fuzes at the points of entry of the mains were not damaged, is curious.

It is possible that this may be due to the tortuous path offered to the discharge by the former as compared with the comparatively straight run through the others.

The writer offers the above conclusions with some diffidence as it is his first experience of this kind, but hopes that where he is wrong he may be corrected by the wider experience and knowledge of others.

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A SIMPLE FORMULA FOR CALCULATING THE STRENGTH OF REINFORCED CONCRETE.

A REPLY TO CAPT. KELSALL'S ARTICLE.

By LIEUT.-COLONEL E. STOKES-ROBERTS, R.E.

IN the February number of the *R.E. Journal* Capt. T. E. Kelsall, R.E., points out that the values of X in the equation $bd^2=\frac{WL}{X}$, as given by the writer in his *Application of Reinforced Concrete* (in India), are, in the case of percentages of reinforcement above 1 per cent., much higher than those given by the formulæ in Capt. Fleming's *Reinforced Concrete*; he also assumes that the writer's values of X were obtained by equating the maximum bending moment of a uniformly loaded beam supported at the ends, with the moment of resistance of the beam for each percentage of reinforcement.

As Capt. Kelsall invites a reply to his article, and as the above formulæ may have been used in places where no copy of the *Application of Reinforced Concrete* has been available, this opportunity is taken of explaining that the values of X, quoted by Capt. Kelsall, were derived (as is stated in the pamphlet in question) from experimental data collected by Mr. F. E. Kidder, and published by him in the 1905 edition of his *Architects' and Builders' Pocket Book*, from which the following quotations are taken :—

"It is obvious that with values for F obtained directly from experimental data, the results obtained by the formulæ will agree with actual tests, whether or not the entire tensional stress is resisted by the steel."

"At or near the breaking point this condition (that entire tensional stress is resisted by the reinforcement) probably exists, but when the load does not exceed one-third of the breaking load, a careful analysis of numerous tests would seem to indicate that the concrete does materially assist in resisting tensile stress."

"In connection with the values of F given in the preceding table, and the stresses assumed, the author recommends that a factor of safety of 3 be used for plain beams."

In the writer's pamphlet the values of X are one-third of the F referred to above, and are stated by Kidder to correspond with a safe stress in the steel of 16,000 lbs. per square inch for plain mild steel bars having an elastic limit of 48,000 lbs. per square inch.

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In 1908 the Royal Institute of British Architects published their *Report on Reinforced Concrete*, and as this, which is probably at the present time the highest British authority on the design of reinforced concrete beams, differs considerably from Kidder in regard to the safe loads for reinforcements above 1 per cent., the writer may perhaps be excused for quoting the following extract from pages 42 and 43 of his *Some Practical Points in the Design and Construction of Military Buildings in India* (published in 1910), which attempts to explain the reason for this discrepancy :—

"10. In view of the interesting and important principle involved in the application of the factor of safety, as discussed below, it seems desirable to see how the formulæ compiled from experimental data and given in Kidder's pocket book (*vide* pp. 21 and 22 of the writer's notes on reinforced concrete) compare with the formulæ given in the R.I.B.A. Report. For this purpose a table has been prepared where item 6 represents the value of M/bd^2 as deduced from Kidder's formulæ, which were worked out from the actual results of a large number of beams tested to destruction.

"As Kidder takes *the working load as one-third of the breaking load*, the values of M/bd^2, as given in item 2 of the table, are one-third of those in item 6, and the corresponding values of bd^2 as given in the writer's Notes (*i.e.* those referred to by Capt. Kelsall) will be found in item 1.

"Items 3 and 4 give the corresponding theoretical stresses in the concrete and steel when the working load is imposed, and it will at once be observed that the stress in the concrete greatly increases as a larger percentage of reinforcement is employed, whilst the converse is the case with the steel; in other words although the factor of safety for the working load remains constant at 3 the factor of safety for the stress in the concrete becomes less as the percentage increases.

"11. The R.I.B. Architects however proceed on the principle usually adopted for ordinary materials of construction that a *given working stress in the concrete or steel shall not be exceeded* whatever the percentage of reinforcement may be, so that the factor of safety is constant for the stresses, and not for the working loads.

"Assuming an ultimate strength for the concrete of 2,700 lbs. per square inch and an elastic limit of 48,000 lbs. for the steel, we see from item 9 of the table (using the smaller values) that the theoretical *breaking load* is in every case greater than Kidder's average test loads in item 6.

"But when we compare the theoretical *working loads* in item 5 with Kidder's working loads in item 2, we find a close agreement in the case of ½ and 1 per cent., whilst a larger working load is allowed by theory for ¾ per cent., and considerably smaller ones for 1½ and 2 per cent., this divergence being due to the different method of applying the factor of safety.

"Now comparing items 3 and 7, and assuming that the concrete will rupture at a stress of 2,682 lbs. per square inch when 2 per cent. reinforcement is employed, we see that with Kidder's working loads the factor of safety for the concrete varies from $2682/473 = 5{\cdot}7$, for ½ per cent.,

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reinforcement, down to 3 for 2 per cent., whereas the R.I.B.A. factor of safety remains constant at $2682/600 = 4{\cdot}4$.

"Finally comparing the *lowest* values in items 5 and 9, (since steel with a yield point of 48,000* lbs. per square inch could certainly not be counted upon under ordinary conditions in this country), we find that the ratio of the breaking to the working load varies from 2 in the case of $\frac{1}{2}$ per cent. reinforcement to 4·0 for 2 per cent., thus differing from Kidder's constant factor of 3.

TABLE.

COMPARING KIDDER'S AND R.I.B.A.'S FORMULA FOR WORKING AND BREAKING LOADS.

Item No.							
	WORKING LOADS—	Percentage of reinforcement	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2
		Corresponding value of percentage in R.I.B.A.'s Report.	·005	·0075	·01	·015	·02
1	Value of bd as given in writer's Notes, where W = safe dist. load in lbs. inclusive of weight of beam, and L = clear span in feet.		$\frac{WL}{45}$	$\frac{WL}{57}$	$\frac{WL}{73}$	$\frac{WL}{100}$	$\frac{WL}{130}$
2	Corresponding values of M/bd^2, where M is the bending moment in inch-lbs.		67·5	85·5	109·5	150	195
3	Stress in concrete in lbs. per sq. in. calculated from R.I.B.A.'s formula $C = \frac{2M}{kbd(1-\frac{1}{3}k)}$.		473	522	608	741	894
4	Stress in steel in lbs. per sq. in. calculated from R.I.B.A.'s formula $t = \frac{M}{pbd(1-\frac{1}{3}k)}$.		15100	13013	12717	11919	11847
5	R.I.B.A. values of M/bd^2.	When concrete stress = 600	85·55	98·29	107·97	121·57	131·10
		When steel stress = 16000 ...	71·5	105·1	137·7	201·3	263·3
		,, ,, = 17000 ...	75·99	111·7	146·4	215·9	279·8
	BREAKING LOADS.		$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2
6	Value of M/bd^2 at rupture as given in writer's Notes, *i.e.*, three times item 2 above.		202·5	256·5	328·5	450	585
7	Stress in concrete in lbs. per sq. in. from formula as in item 3.		1419	1566	1824	2223	2682
8	Stress in steel calculated as in item 4		45300	39039	38151	35757	35541
9	R.I.B.A. values of M/bd^2 at rupture.	When concrete stress = 2400	342·2	393·2	431·9	486·3	524·4
		,, ,, = 2700	375	442·3	485·8	547·1	589·9
		When steel stress = 32000	143	210·2	275·4	402·6	526·6
		,, ,, = 48000	214·6	315·4	413·1	604·1	790·1

* The yield point of Cossipore mild steel bars is from 31,000 to 36,000 lbs. per square inch.

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"12. It remains only to decide which method to adopt, and the experienced designer will have no difficulty in deciding any case on its merits, bearing in mind that in the present state of knowledge the R.I.B.A. formulæ are admittedly only approximate.

"For ordinary *moulded* reinforced concrete (1:2:4) work the writer will adhere to the formulæ in item 1 on account of their extreme simplicity, but will increase the devisor for $\frac{3}{4}$ per cent. from 57 to 60, as 57 really corresponds to a percentage of ·0071 and not ·0075. It may also be pointed out here that the whole weight of the beam should be included in the working load, and not one-third, as is incorrectly stated in Kidder's pocket book, and repeated in the writer's Notes.

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"14. Any percentage above $1\frac{1}{2}$ must be used with caution and then only when there is no probability of the working load being exceeded to any appreciable extent (as in the case of rafters and bressummers), for as will be seen from items 7 and 8 of the table, the concrete is severely stressed as a highly reinforced beam approaches rupture, whilst the steel is still well within its elastic limit, so that when failure does occur it will be owing to the crushing of the surface of the concrete under compression, and will consequently be sudden and with little or no previous warning. On the other hand with low percentages the failure will be due to the yield point of the steel being exceeded, and ample warning of coming rupture will be observable from wide cracks opening up in the lower surface of the concrete."

Now, as a very large number of moulded beams, rafters, etc., designed from Kidders' formulæ (in some cases with only one-third of the weight of the beam itself deducted from the working load) for the barracks at Jubbulpore and Ahmadnagar and probably elsewhere, with reinforcement as high as $1\frac{1}{2}$ per cent., have behaved admirably and give no cause for anxiety, the writer's remarks in para. 12 above appear to be justified, bearing in mind the caution given in para. 14, and that the moulded reinforced concrete rafters, etc., he refers to can only, from the nature of the case, be used in positions where the working load is not likely to be largely exceeded. It would be inadvisable to use the Kidder formulæ for beams containing a high percentage of steel and forming part of a floor or other portion of a building where the assumed working loads may on occasions be much exceeded.

It should also be pointed out that in moulded work it is necessary to place a certain amount of reinforcement in the upper (compressive) portion of the beam, to provide against improper handling before the beam is placed in position, and, although this extra steel is not taken account of in the Kidder formulæ, it adds materially to the strength.

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The following table summarizes the differences between the R.I.B.A. and Kidder formulæ for *working loads* :—

Percentage.	¼	½	1	1½	2
Values of X in formula $bd'^2 = \frac{WL}{X}$ { Kidder	45	60	73	100	130
{ R.I.B.A.	47·2	65·8	71·5	81	87
Theoretical stress in concrete from R.I.B.A. formulæ. { Kidder	473	550	608	741	894
{ R.I.B.A.	495	600	600	600	600
Theoretical stress in steel from R.I.B.A formulæ. { Kidder	15,000	13,700	12,717	11,919	11,847
{ R.I.B.A.	15,900	15,000	12,400	9,550	7,950

It will be seen from the above table that for reinforcement higher than 1 per cent. the stresses in the steel are very low in the case of the R.I.B.A. formulæ, and that, with the working load allowed by Kidder, the stress in the concrete rises to nearly 50 per cent. above the 600 lbs. per square inch permitted by theory.

As is well known the actual tensile stress in the lower flange of a cast-iron beam must be less than is indicated by theory, and by analogy it may perhaps be correctly argued that the real compressive stress in the concrete of the upper fibres of a reinforced beam is less than the theoretical one.

From this point of view the following quotations from Claxton Fidler's treatise on Bridge Construction may be of interest :—

"The lateral adhesion (between the fibres) does not alleviate the tensile stress in the outmost fibre in the manner erroneously supposed by some writers, for its action is evidently exerted in doing the opposite thing."

"The difference between the actual breaking weight of a beam and that which, theoretically, produces the ultimate tensile stress, may perhaps be partly explained by a certain shifting of the neutral axis . . . , but this can never account for more than a small part of the discrepancy which is observed in practice, and which has never been explained."

"In the meantime we can only determine the strength of a beam of any given material by direct experiments on cross breaking."

It must be admitted however that formulæ based on experimental data are rarely used, and that either the R.I.B.A. theory or a close approximation to it is adopted in general practice, but at the same time the present deficiency in theoretical knowledge is testified by the numerous tests and experiments now being carried out in almost every country by universities, institutes, etc.

Capt. Kelsall refers several times in his article to the "economical ratio" of tensile reinforcement, which, ordinarily speaking, is in the neighbourhood of ¾ per cent., since the concrete and steel will then be theoretically stressed at not far from the assumed working limits of

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600 and 16,000 lbs. per squre inch respectively, but in practice there are often other considerations which render it desirable to employ an excess of steel in order to reduce dimensions, or to obtain greater strength with given dimensions. Where reinforced concrete is used in the form of rafters, etc., it is necessary to keep down the weight on account of ease in handling, so that the higher percentages may often be required.

Again it by no means follows that because the steel and concrete are working at or near their limiting stresses, the most economical design has necessarily been attained, and this point is discussed in Turneaure and Maurer's *Principles of Reinforced Concrete Construction*, where it is shown that the maximum economy of construction may sometimes be obtained by using less than the allowable working stresses in one or the other of the two materials.

The cost of a rectangular beam to support a given moment M, varies inversely as the depth, directly as the square root of the breadth, and directly with the cube root of the ratio of breadth to depth ; but the depth may be limited in various ways, *e.g.* by the headroom required, or by the fact that a certain breadth is necessary to cover the steel properly, or to give a satisfactory proportion to the beam, or finally to give sufficient strength against shear. Again the breadth may be fixed as in floor slabs.

When the cost of steel per unit volume is 25·4 times that of concrete the most economical reinforcement will be as follows :—

Depth fixed ; 2 per cent. reinforcement at both the top and bottom of the beam.

Breadth fixed ; $\frac{3}{4}$ per cent. reinforcement at the bottom and one-fifth of this (0·15 per cent.) at the top of the beam.

Ratio of breadth to depth fixed ; 1 per cent. reinforcement at the bottom and 0·8 per cent. at the top of the beam.

When however the cost of the steel per unit volume is as high as 50·8 times that of the concrete, the economical reinforcement will be as given below :—

Depth fixed ; there is no difference in cost between (*a*) $\frac{3}{4}$ per cent. at the bottom with no steel at the top of the beam, and (*b*) 1 per cent. at the bottom and 0·4 per cent. at the top of the beam.

Breadth fixed ; in this case, also, the use of $\frac{3}{4}$ per cent. at the bottom with no steel at the top of the beam is the most economical arrangement.

Ratio of breadth to depth fixed ; here again $\frac{3}{4}$ per cent. will be best for the bottom with the addition of 0·3 per cent. in the top of the beam.

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TRANSCRIPTS.

THE CAVALRY MARCH TO CAIRO.

By COLONEL SIR C. M. WATSON, K.C.M.G., C.B.

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HAVING had the good fortune to take part in the rapid advance of General Sir Drury Lowe with the cavalry after the defeat of the Egyptian Army at Tel-el-Kebir, and to command the small force which occupied the citadel of Cairo and turned out the Egyptian garrison, I think it may be of interest to give a short account of the operations. I was attached to the cavalry division as intelligence officer the day before the Battle of Tel-el-Kebir.

The cavalry division was ordered to take up a position on the extreme right of the British Army, quite clear of the right infantry division, so as to avoid any risk of confusion with the latter in the dark.

At 12.45 a.m. on September 13th General Lowe gave the order to march, the Bengal Lancers leading. A flagstaff had been fixed at some distance in the desert to mark the proper direction for the column; but, after this had been reached and passed, it was necessary to move by compass, aided by the stars which shone here and there through broken masses of cloud. In places the deep sand of the desert muffled the sound of the horses' hoofs, and viewed from a short distance the column looked like a spectral body of troops moving noiselessly through the darkness.

At 3 a.m., as the division had reached what appeared to be the correct position, the order was given to halt, there to wait until the infantry attack on the lines of Tel-el-Kebir had commenced. The men took what rest they could, holding their horses, and wishing for the day to break. Just as the first glimmer of light appeared in the east, the order was given to mount. Immediately afterwards the dull boom of a gun far away to the left, followed by the roll of musketry, and then the continuous crash of artillery and rifle fire combined, told us that the struggle had begun.

The cavalry advanced at a trot. When we came in sight of the entrenchments I noticed an Egyptian battery in action on the left flank of the works, but this was quickly silenced by the horse artillery, and the Egyptian gunners ran away. Not far from us, on the left, the infantry of General Graham's brigade were seen crossing the lines, and the cavalry passed the latter at a point near the Egyptian battery already mentioned. Here the entrenchment was very weak, being little more than a shallow ditch, which was practically no obstacle to horsemen or guns. After crossing the lines the cavalry wheeled to the left, and rode southwards inside the works, driving the flying Egyptians before them.

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When the division had advanced some distance, the heavy brigade was halted, while the Indian cavalry pushed on to the line of railway near Tel-el-Kebir Station, pursuing the routed Egyptians, who were trying to escape into the country. Some trains which were standing in the vicinity of the station were filled with fugitives, and two of these succeeded in getting away, but the third was stopped. Arabi Pasha himself, having failed to escape by train, mounted his horse, and, with some of his staff, fled in the direction of Belbeis, about 18 miles distant, not giving much thought to the fate of his army.

General Lowe ordered General Wilkinson to continue the pursuit with the Indian cavalry brigade and the Mounted Infantry along the north bank of the freshwater canal, and I was directed to lead the column. Lowe himself waited at Tel-el-Kebir to meet Sir G. Wolseley, and then, as soon as the heavy brigade and the horse artillery came up, took them across the bridge and marched by the south bank. At Belbeis the two brigades were to unite for the march to Cairo.

I had a good general idea of the road to be followed, and knew that there would be no difficulty except at the point where the branch canal, coming from Zagazig, joined the main canal at El Abbasa, as there was no bridge there. But, fortunately, there was a footbridge at the lock, over which the cavalry were able to march in single file. It was well that there was no artillery, as it would have been a somewhat difficult matter to get the guns over.

After crossing, at the village of El Abbasa, the troops halted a short time to water the horses. The inhabitants came out to meet us, waving flags and asking for peace. They probably feared that the British soldiers would burn their houses and carry off their goods, but were soon reassured when they found that they received kind words instead of ill-treatment.

The Egyptian soldiers were flying before us in hundreds, and made no attempt at resistance. The action at Tel-el-Kebir had taken away any courage they may have possessed, and their sole thought was to get home as quickly as possible. They were ordered to throw down their rifles and ammunition, and to go where they liked; many of them stripped off their uniforms also, and, in the twinkling of an eye, were transformed into harmless peasants. The rifles were left on the ground, and years afterwards I came across some of these Remingtons in the hands of tribesmen in the Jordan Valley, and was told that after the British cavalry had passed many of the rifles were collected by the Beduin, who, later on, did a good trade by selling them to the Arabs in the Sinai Peninsula and elsewhere.

It was a warm September morning, and one looked with longing eyes at the shady groves of palm trees which were passed as we rode along. As the column approached Belbeis there was a slight attempt at resisting its advance, and a few shots fired from a group of palms on the right showed a feeling which it was necessary to check at once, so the Mounted Infantry opened fire, and the Indian cavalry formed line and advanced at a trot, upon which the Egyptians disappeared.

Then we saw some distance ahead a small body of mounted Egyptians

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making off as fast as they could, and, from information I obtained afterwards, it seems probable that this was Arabi and his party on their way to Cairo. He arrived at Belbeis only a short time before us, and finding a train coming from Cairo, had the engine detached, and, mounting on it, told the driver to go to Cairo "like the wind." He seems to have been the first person to bring the news of his own defeat at Tel-el-Kebir—rather a unique position for the general of an army.

Shortly before noon we saw the minarets of Belbeis standing out sharply against the clear sky. Soon afterwards the bridge over the canal was reached, and the first part of our march to Cairo was completed. General Wilkinson directed me to seize the railway station, the telegraph office, and the post office, and to bring him the Governor of the town. So I took a small escort and proceeded to the station, which was on the other side of the town and at a considerable distance from the canal.

It was probably many years since the bazaars of that quiet little place had been so excited, and it was quite a scene for an artist, as the inhabitants, dressed in every kind of eastern garb, swarmed round the British officers and their Indian escort, while the notables expressed the delight of the town at the arrival of the British Army. Perhaps what they said was true, as no doubt all they wanted was peace and quiet, but I am inclined to think that they would have said something of the same kind to Arabi's officers 24 hours earlier. On arriving at the station I went into the telegraph office to see what was going on. There were some interesting telegrams just received from Arabi, who had reached Enshas, the next station on the way to Cairo, where he had stopped to telegraph to the officer in command at Salahiyeh, ordering him to send his troops at once by train to Mansureh. In another telegram he asked for news as to the movements of the English, but as no reply was sent to his messages he probably assumed that Belbeis was captured, for he went on at once to Cairo.

Late in the afternoon General Lowe, Colonel Baker Russell, and Colonel H. Stewart arrived with the 4th Dragoon Guards, and we then heard that the heavy brigade and the horse artillery had been much hampered in their advance in consequence of having to cross a number of small canals. General Lowe decided to make an early start on the morning of September 14th, and we were all up and ready for the advance soon after 3 a.m. But there were still no sign of the missing brigade and the guns, so, after waiting an hour, he decided to proceed without them.

The column, about 1,200 strong, consisted of the 4th Dragoon Guards, the 2nd Bengal Cavalry, part of the 6th and 13th Bengal Cavalry, and the Mounted Infantry.

The sun had not yet risen, and the morning air was cool and refreshing, while the hard, gravelly surface of the desert made good going for the horses. There were no more Egyptian runaway soldiers to be seen, and the inhabitants of the villages which we passed seemed all to be peacefully disposed. Two Egyptian officers, Dhulier Bey, a Belgian, and Hussein Effendi Ramsi, who had been sent by the Khedive to Ismailiyeh,

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and were attached to General Lowe's staff, read out, every now and then, a proclamation to the villagers, assuring them of peace and security if they were faithful to the Khedive. To this the people replied with loud cries of "Aman," "Aman," "Peace," "Peace." Not a word of regret was to be heard for the defeat of Arabi, which had by that time become generally known.

As the morning wore on and the sun rose higher in the sky, the heat steadily increased until it was like that of a furnace, but no halt was made until a little after noon, when we reached the village of Es Siriakus, about 25 miles from Belbeis. Here some food for the men and forage for the horses were easily obtained, and an hour's rest under the shade of the palm trees was much appreciated.

When the column started again we left the canal, which had been followed from Belbeis, and went into the desert so as to avoid the low ground, broken up with little irrigation canals and not suitable for the movement of cavalry. We were now drawing near to Cairo, and naturally our conversation turned to the question as to what kind of reception we were likely to meet with, as it was known that there was a garrison of about 20,000 troops which had not fought at Tel-el-Kebir, and which might be prepared to resist our advance to the capital. I told the General and Herbert Stewart of what we had heard as to the probability of Cairo being burnt like Alexandria, and pointed out the great importance of putting British troops in the Citadel that evening. There is an old Egyptian saying, "He who holds Cairo holds Egypt, he who holds the Citadel holds Cairo," and it was almost certain that once the population knew that the Citadel was in the possession of the British, all resistance would collapse. But it was, of course, not possible to say how the Citadel was to be secured until it was known what the Cairo garrison would do, and whether Arabi would spur them on to fight, or would bow to fate and acknowledge that he was beaten at Tel-el-Kebir.

Soon we saw the line of the Mokattam Hills, which rise sharply over the city of Cairo, and then gradually we could make out the dome and minarets of the mosque of Mohamed Ali in the Citadel. An hour more brought us within sight of the great barracks of Abbasiyeh, situated in the desert, 2 miles north-east of the city, round which we could see thousands of Egyptian soldiers swarming, and looking just like ants whose ant-hill has been disturbed. General Lowe ordered his force to advance by echelon of squadrons from the left, making as great a show as possible with the small number he had under his command. Then he halted the cavalry and sent Colonel Stewart forward to reconnoitre and to see what was going to happen.

Stewart took an escort of 50 men, and, accompanied by Lieut.-Colonel H. M'Calmont, the Brigade Major, the two Egyptian officers, and myself, started on his mission of investigation. We rode on towards the barracks, and saw an Egyptian squadron of cavalry coming out to meet us, every man of whom had a white flag, or something that represented a white flag, tied to his carbine. The Abbasiyeh garrison had decided to surrender, and was determined to do it in good style!

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It may be interesting to relate what happened in Cairo while the British cavalry were advancing from Tel-el-Kebir, and I will give the account as described to me afterwards by one of the members of the Egyptian Council of Defence. It was known in Cairo that the British Army had concentrated at Kassassin on September 12th, and that there might be a battle at any time, but when it would come off was of course uncertain. As I have already mentioned, Arabi Pasha, escaping from Tel-el-Kebir after the fight, had got to Belbeis and started from it by rail just before General Wilkinson's column arrived. When Arabi reached Cairo, he went to the Kasr-el-Nil Palace, where the Council of Defence were holding a meeting. He was tired out, and quite collapsed when he sat down; then raising his head after a time, he said, "It is all finished," and told the Council of the defeat of the Egyptian Army, and that the English would soon be in Cairo. Then there was a great discussion as to what was to be done. Some were for making further resistance, while others were for sending their submission to the Khedive. A little later news came in that the British had taken possession of Zagazig, which General Macpherson, with the Indian contingent, had occupied on the afternoon of September 13th.

General Macpherson, as soon as he reached Zagazig, telegraphed to Cairo to announce his arrival, and, late that evening, the Egyptian Council decided to send a deputation to the Khedive offering their submission to him, and they sent a telegram to Sir G. Wolseley informing him of the fact, and begging him to take no further action "until you receive orders from His Highness the Khedive." There can be no doubt that the Council wanted, as the Chinese say, "to save their face"; they wished it to be understood that they made their submission to the Khedive, *not* to the Commander-in-Chief of the British Army.

Nothing more, according to my informant, was done that night, but the next morning when they found that the British had not yet arrived the more warlike members got in the ascendant, and it was decided to take steps for defending Cairo in case the British Army advanced towards it. It was arranged that entrenchments should be thrown up in front of Abbasiyeh, and an engineer officer was sent to carry this out. The line was traced and the work of digging had actually begun when the small force of cavalry under General Drury Lowe was seen in the distance, and a messenger was sent in at once to the Council to inform them that "the whole English Army was arriving."

Then there was naturally the greatest excitement, and the members of the Council were at their wits' end what to do. I was never able to ascertain whether they came to any decision, nor whether they sent orders to the garrison of Abbasiyeh to surrender, but I am inclined to think that it was a case of every man for himself, and that the Commander of the troops at that place decided that it was the best policy to surrender, no matter what the Council might do. But, however that may be, there can be no doubt that when Colonel Herbert Stewart and his handful of men approached the Abbasiyeh Barracks, the Commanding Officer came out to meet him, and surrendered, unconditionally, with his force of cavalry, artillery, and infantry, about 10,000 in all.

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It was quite a dramatic scene: in the centre was the little group of British and Egyptian officers discussing the terms of surrender, while on the one side were the British and Indian troopers, and on the other the squadron of Egyptian cavalry; behind, the white mass of the Abbasiyeh Barracks, about which we could see great numbers of Egyptian soldiers —some drawn up in column, and some wandering here and there like sheep without a shepherd. Then, as a background, Cairo in the distance, and beyond all the Eastern sky, bright with the red gleam of the setting sun.

The preliminaries were soon arranged, and then the British advance guard moved on to the barracks, while Stewart sent me back to General Lowe to tell him that all was well. As soon as the troops heard that Abbasiyeh had surrendered, they gave a ringing cheer, and were then ordered to close up and advance. The greater part of the cavalry, however, were kept out in the desert, and not brought into the barracks, as the General thought it wiser not to let it be seen what a small number of men he had with him.

Immediately after the surrender at Abbasiyeh, Colonel Stewart ordered the Commanding Officer to send to Cairo and summon the Governor, the Chief of Police, and the Commandant of the Citadel, and these gentlemen all came out in a short time and tendered their submission to General Lowe. The Chief of Police was asked for information about Arabi Pasha, and stated that he was in his own house; he was directed to return to Cairo and bring Arabi out to Abbasiyeh. The Governor and the Commandant were then informed that the Citadel must be surrendered that evening. The Governor begged General Lowe not to send any troops into Cairo that night, as he feared it might cause a disturbance; but the real danger was, of course, that if British troops did not occupy the Citadel at once, the evil-disposed people of the town would feel that there was no one in authority and would do mischief. After some discussion the Commandant agreed, though rather reluctantly, to surrender the Citadel, if required to do so.

After darkness had set in, Colonel Stewart informed me that he was to take a small force of cavalry and occupy the Citadel, and that I was to take possession of the fort on Mokattam heights, which commanded the Citadel, with another small force. This seemed a very satisfactory arrangement, as it was desirable that the Egyptians should be turned out of both these positions before the sun rose, and before the people realized what an insignificant British force had reached Cairo. The hour named for the start was 8 p.m., as it was important that we should not march until it was quite dark.

At that hour, when the troops were falling in, Colonel Stewart told me that the plan had been changed, and that he was to remain at Abbasiyeh with General Lowe, and that, as I knew Cairo, I was to take command of the force which was to occupy the Citadel and turn out the Egyptian garrison. He gave me no written orders, and said that I was to carry out the operation in whatever way I thought best. I asked him what was to be done about the fort on Mokattam, as it was impossible for me to go to both places at the same time, and he replied that I must use my own

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discretion with regard to it. Although it was a certain responsibility, it was, on the other hand, rather satisfactory not to be hampered by detailed orders, as I was thus able to make my own arrangements.

The force placed at my disposal by Colonel Stewart consisted of 5 officers and 84 non-commissioned officers and men of the 4th Dragoon Guards, under Capt. Darley; and 4 officers and 54 non-commissioned officers and men of the Mounted Infantry, under Capt. Lawrence. I also took with me Hussein Effendi Ramsi, who had come with us from Tel-el-Kebir, and three of Arabi's officers, one of whom, an engineer, had been employed on strengthening Abbasiyeh against us a few hours before. I made it clear to these officers that their future in life depended on doing exactly what I told them, but they fully realized the situation and were very helpful.

As it was important that we should not be seen by the inhabitants of Cairo until close to the Citadel, I decided not to enter the town by the Bab Husseiniyeh, the gate nearest to Abbasiyeh, but to follow the desert road leading by the Tombs of the Memluk Sultans, commonly called the Tombs of the Caliphs, and to enter by a small and little-used gate called the Bab el Wezir, which is just under the Citadel. It was very important that we should find this gate open, as if it was closed it would have been necessary to go round to another gate some distance off, and this would have lost considerable time. The engineer officer, who was thoroughly acquainted with the fortifications of Cairo, assured us that we would find the Bab el Wezir open, and as his own interests depended on his telling the truth, I decided to trust him.

As soon as the little force had fallen in I marched them off, and then rode to the head of the column, telling each file as I passed that they must never lose sight of the file in front of them: this was essential, as the night was pitch dark, and, with the dust raised by the horses, it was difficult to see more than a few yards ahead. Those who know the road in the daytime will understand that it is not an easy one to follow on a dark night, but my Egyptian guide knew it thoroughly, and I soon felt that he could be trusted to lead us right.

We first crossed the desert for about 2 miles, then passed through the great cemetery of Kait Bey and over mounds of rubbish, full of holes, which were hard to avoid in the dark; and we seemed to have ridden for an interminable time when at last the walls of Cairo rose before us. Then we drew near to the Bab el Wezir, and I became a little anxious lest it should be shut after all. But when we got close the door stood open, and I rode through the dark tunnel and found it quite clear to the far end; neither was there a sign of a sentry nor of anyone watching the gate, so I brought our party through and led them up the hill to the Citadel.

The street leading up from the gate was very narrow and very steep, and the houses on each side were in darkness, except for the little shops below, in which were collected a number of people who looked at the British soldiers with surprise, probably not unmixed with fear. At the end of this short street we turned to the left into the broad road, leading up to the main gate of the Citadel; and I halted the party at a little

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distance from the gate, and went on to the gate with the Egyptian officers to see how matters stood.

There was a strong guard on the gate, who evidently had not expected us, and it was soon clear that, notwithstanding the promise of the Commandant, no arrangements had been made for sending the Egyptian garrison out of the Citadel. I therefore ordered the officer in charge of the guard to go to the Commandant and tell him to come to me at once. This took a considerable time, and I am inclined to think that the good Commandant had gone to bed.

He came out at last, however, accompanied by a number of officers, and asked what I wanted him to do. I said that he must parade the whole garrison without any delay, and send them down to the Kasr-el-Nil Barracks, in the lower part of Cairo. I said that I had brought a British force to garrison the Citadel, and that the keys of all the gates were to be handed over to me at once. He seemed a little doubtful at first, but not having any idea how many men we had, he decided to comply, and sent for the keeper of the keys, who brought a number of very large keys in a beautiful bag, and handed them over. Then the Commandant sent officers to the different barracks, and soon bugles were heard all over the Citadel sounding the assembly, and the troops began to hurry out of their quarters and to fall in on the large open space between the mosque of Mohamed Ali and the mosque of Nasr ebn Kalaoun.

As I was anxious not to let the Egyptian troops pass our small party, I arranged to march them out by a different road to that by which we had come up. Those who know the Citadel will remember that there are two principal entrances, of which one, the Bab el Azab, or lower gate, is in the Place Rumeyleh, opposite the great mosque of Sultan Hassan. This was the old entrance, and from it a steep road, the scene of the massacre of the Memluks by Mohamed Ali in 1811, leads up to the Bab el Wastani, or middle gate. The present principal entrance, on the other hand, known as the Bab el Gedid, or main gate, which was built by Mohamed Ali when he reconstructed the Citadel, is much higher up the hill; the road passing through it joins the road leading up from the Bab el Azab, just outside the middle gate. This disposition of the gates was very convenient for my purpose, as I was able to place our men on the road leading from the main gate to the middle gate, while the Egyptian troops were marched out by the steep road, which went down to the Bab el Azab, and did not pass by our men. One of our officers and a couple of men were placed at the Bab el Azab, to hurry them out into the town.

I was considerably struck with the good discipline of the Egyptians, who fell in by companies and marched off as if they were quite accustomed to being roused up in the middle of the night and turned out by foreign troops. But, in addition to the regular soldiers, there were a great number of what appeared to be camp-followers—women, laden camels, donkeys, etc.—and these hurried out of the Citadel with the troops, much interfering with the regularity of the march of the latter. For more than two hours the stream of Egyptians came out through the middle gate,

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and it was past midnight before the last stragglers went down the hill. As already mentioned, I had ordered them to go to Kasr-el-Nil Barracks, but a considerable number never arrived there, as they took the opportunity, while marching through the streets of Cairo in the dark, of slipping away and going to their homes. This, however, was a good thing, as they were useful messengers to spread the news of how they had been turned out of the Citadel by the English Army.

While watching the strange procession at the gate, I thought over the question of the fort on Mokattam heights, and considered how the Egyptian troops were to be got out of it. It was clearly no use trying to do it with our troops, as none of our officers knew where it was, and the men and horses were too tired for another expedition. At last a happy thought struck me, and I hailed an intelligent-looking Egyptian officer on his way out of the Citadel, and said that I would be much obliged if he would go up to the fort, send the garrison to Kasr-el-Nil, lock the gate, and bring me the keys. He thought for a moment, then said, "Hadir, ya Sidi." "All right, sir," and went off at once. From his manner he gave me the idea that he would carry out his mission; and my confidence was justified, as he came back in two hours with the keys.

Before leaving Abbasiyeh, Colonel Stewart had instructed me that, after I had cleared out the Citadel, I was to leave the next senior officer in command for the night, then to examine into the condition of Cairo, and return to Abbasiyeh to report to General Lowe. As soon, therefore, as the garrison had evacuated the Citadel, I told Capt. Lawrence, the next senior and an excellent officer, that he was to take command when I left, and took him round to give him a general notion of the fortifications. I had been acquainted with the place some years before, and had a fairly good idea of the important points, but to one who saw it for the first time on a dark night it must have seemed a puzzling labyrinth. Hussein Ramsi and the engineer officer accompanied us, and sentries were posted on the different gates with orders to let no one in or out during the night.

The Citadel seemed quiet, and I thought our task was over, but as Capt. Lawrence and I were returning to the middle gate, we were rather startled by hearing a tremendous noise, shouting and clanking of chains, as if pandemonium had broken loose. We then found that the din was caused by the prisoners, of whom there were many hundreds, who had been roused by the sound of the departing garrison, and had opened the prison door and were trying to escape. We succeeded in driving them back, and then went into the prison, which smelt badly. Here were a great number of prisoners, closely packed together, some regular jail-birds, and others who looked as if they might be respectable members of society.

The latter crowded round us, and said that they had been put in prison because they would not support the rebels, and they asked me to investigate their cases immediately and release them. The idea of holding a court under the circumstances was rather humorous, and I told them that it was impossible to do anything for them that night, but that as the English had taken possession of Cairo their cases would be gone

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into as soon as possible, and justice would be done. The following day, when Colonel Sir Charles Wilson arrived in Cairo, I told him of the state of the prison in the Citadel, and he obtained authority to go into the matter, and to release all those persons who had been imprisoned without due cause.

Having quieted the prisoners as far as possible, we went out of the prison, the doors were locked, and sentries were posted with orders to shoot anyone who tried to escape. Notwithstanding this, I believe that a certain number did succeed in getting away after I left the Citadel, and I know that one man at least was shot. This was an inoffensive individual, coachman to one of the American officers in the Egyptian Service, who had been put in prison because he was supposed to be in favour of the Europeans. Fortunately he was not much hurt, and soon recovered.

After the episode with the prisoners had concluded satisfactorily, I went with the Commandant to his quarters to discuss the situation. Having been a supporter of Arabi, he was naturally anxious as to his prospects, and inquired whether I was satisfied with the way he had acted. I told him that he had behaved admirably so far, but that he must remain in the Citadel for the night and do all he could to assist Capt Lawrence, explaining to him at the same time that if anything disagreeable happened he would be held responsible. I then questioned him as to the composition and strength of the Egyptian garrison which had been in the Citadel, but rather curiously, neither he nor his officers could give a definite account of the number of men, and their estimates varied from 5,000 to 7,000. By a rough calculation I had made while they were marching out, there were about 6,000, and this number, or perhaps a liitle more, was probably nearly correct.

After again giving a word of caution to the Commandant, I bade him good-night, and went with Capt. Lawrence to the main gate. Here the Egyptian officer had just arrived who had carried out the evacuation of the fort on Mokattam heights, and I thanked him for having assisted me, and let him go home. Then, leaving Capt. Lawrence in charge of the Citadel, I started to carry out the second part of my instructions as regards the examination of the state of Cairo, taking with me Hussein Ramsi and the engineer officer.

We followed the main road down from the Citadel to the mosque of Sultan Hassan, aud then proceeded along the Boulevard Mohamed Ali to the Esbekiyeh Gardens. Cairo was like a city of the dead: the news of the occupation of the Citadel by the English had become known, and the inhabitants wisely kept to their houses. The engineer asked if we might go round by his home to get his greatcoat, as the night was chilly. So we made a detour, and I found all the streets we rode through equally tranquil. It was rather a curious situation: here was I, an officer of the invading army, riding quietly through what had been supposed to be a hostile city, having as companion an officer of the enemy who, less than 12 hours before, had been preparing to put Abbasiyeh in a state of defence against us; and yet it seemed quite natural, and as if there had never been a war at all.

After passing the Esbekiyeh, we rode by the Coptic quarter of the

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town, which was also perfectly quiet, though, as I learned afterwards, the Copts had been in a great state of anxiety since the defeat of Arabi at Tel-el-Kebir, and were much relieved when they heard that Cairo was in the possession of the English, and that all danger was past. Then we went on to the Fagalla; and as by this time I had been through the city from one end to the other, I had seen sufficient to justify me in reporting to General Lowe that Cairo was peaceful. So we took the road to Abbasiyeh by the mosque of Zahir, and reached the barracks a little after 4 a.m., just 25 hours since we had prepared to start from Belbeis. It had been an interesting day, but I was not sorry it had come to an end at last.

On entering the barracks I went to find Colonel Stewart, who told me that during my absence in Cairo Arabi Pasha and Toulba Pasha had come out from the city and surrendered. The Egyptian military revolt was at an end. Stewart took me to General Lowe, to whom I reported that all had gone well at the Citadel, and that Cairo was perfectly quiet. He said, "Well done," and in a few minutes we were all asleep.

The next morning General Lowe ordered me to accompany a squadron to the railway station to meet Sir Garnet Wolseley, who was expected to arrive by train from Zagazig, where he had been delayed by a breakdown on the line; so he did not reach Cairo until 9.45 a.m. On returning from the station, I made a written report to General Lowe respecting the surrender of the Citadel, and strongly recommended the Commandant for favourable consideration. I am glad to say that, though he was a senior officer of the Egyptian Army, and a great supporter of Arabi, he received a free pardon from His Highness the Khedive.

The engineer officer was, of course, also pardoned, and a few months later, when I was employed under General Sir Evelyn Wood on the organization of the new Egyptian Army, he became one of my subordinates in the War Office. We often talked over the night of our first acquaintance, and he asked me once whether there was any chance of his getting the British war medal. I told him that, though I was greatly obliged to him for his assistance on the night of September 14th, it was not in accordance with English custom to give medals to officers of the enemy's forces. But there can be no doubt that but for the cordial way in which he and Hussein Effendi Ramsi assisted me, it would have been much more difficult to carry out General Lowe's instructions.

The cavalry march to Cairo affords an excellent instance of the importance of following up a beaten enemy without an instant's delay, and Sir Drury Lowe is worthy of the highest credit for the manner in which he carried it out. It is to be regretted that in the *Official History of the Campaign*, published by the War Office in 1887, neither Sir G. Wolseley's orders to General Lowe nor that officer's report upon the march is given. As regards the former, all that is stated is "that the cavalry were directed to continue their pursuit, and advance upon Cairo with all possible rapidity, to save it, if possible, from the destruction intended by Arabi Pasha." Apparently this meant that Lowe was to take the whole of the cavalry division to Cairo. If this is so, he took a considerable

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responsibility on himself in leaving the greater part of one brigade and the whole of the artillery behind when he started from Belbeis; but his action probably saved the situation, as, if he had waited for the heavy brigade and the guns, he would not have reached Cairo until September 15th.

What would have occurred in the interval it is, of course, not possible to say with certainty, but one of two things might have happened. Either the forward military party would have taken the lead, and an attempt would have been made to defend Cairo with its large garrison, or else the fanatical Mohamedans would have put Arabi and his colleagues on one side, and Cairo would have been treated like Alexandria. In either case the result would have been disastrous for the city.

In after years I often discussed the question with Egyptians who had lived in Cairo during the war, and met many who thought the latter event the more probable. The Coptic Patriarch, for example, used to say that he was sure there would have been a massacre of the Copts on the night of September 14th, had it not been for the arrival of the British cavalry on the afternoon of that day, and their taking possession of the city. The burning of Alexandria might without any doubt have been prevented, if British troops had landed immediately after the bombardment; but the unfortunate delay in that case led to the loss of many lives, and the destruction of property of the value of £4,000,000, which Egypt had to pay.

It is probable that the rapid advance of Sir Drury Lowe saved Cairo from a similar fate.

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METHODS OF COMMUNICATION IN THE ENGLISH ARMY.

Translation by Lieut. F. S. G. Piggott, R.E., of a lecture by Capt. Shintarō Koriyama of the Engineers.*

THE scope of this lecture, from its mere title, "Methods of Communication in the Army," is very wide, but I only propose to give here an outline of the two principal methods, viz.: communication by means of electricity and communication by means of signalling.

In the English Army the methods of electrical communication adopted are the telegraph, the telephone, and wireless telegraphy. Of these, telegraphy and wireless telegraphy are in the hands of special troops, and the telephone is distributed also among all field units by whom it is very much used.

I will now give an outline of the telegraph units and telephone detachments. The kinds of telegraph units and their *personnel* are as follows:—

The Divisional Telegraph Company.—There is one company, attached to each division, whose duty is to keep up communication between the divisional headquarters and brigade headquarters, or artillery. It is capable of laying 30 miles (48 kilometres) of insulated wire and of establishing six telegraph stations. It is divided into three sections, each section having one cable cart (with 8 miles of insulated wire) and one light four-wheeled wagon, (with 2 miles of insulated wire, and instruments, boxes, etc.).

The Cable Company.—The object of this company is to keep connection with army headquarters and divisional headquarters, and it is capable of establishing 80 miles, (128 kilometres), of insulated wire, and 24 telegraph stations. It is divided into four sections, each section having two cable carts and one light four-wheeled wagon, exactly similar to those used by the divisional telegraph company. These cable carts consist of limber and wagon, and are drawn by four horses: on the limber are carried the instrument boxes and telegraph stations, and on the wagon four cable drums each with 2 miles of cable. The operators for unreeling the wire and laying it along the ground, ride on the carts: as the rate of laying the line can be increased up to the speed of a horse galloping, it is very suitable when rapidity is necessary.

The Air-Line Company.—This is used when changing the cable of an already-laid line to bare wire, and also for establishing communication between army headquarters and divisional headquarters when great speed is not essential. Each company has sufficient *personnel* and material to erect 60 miles of wire (96 kilometres) and 12 telegraph stations; also

* The various establishments, etc., are as given in the lecture and must not necessarily be taken as correct.

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there are sufficient men to maintain 120 miles (192 kilometres) of line. It is divided into four sections, each having four 4-wheeled wagons with material for 5 miles of line: each wagon also has instrument boxes and the material for one telegraph station. Further, the company has a cart for spare stores, which include 8 miles of insulated wire.

The Wireless Telegraph Company.—Its *rôle* is to keep connection between army headquarters and the cavalry division. A company is capable of establishing four stations; the system at present in use is the Lodge-Muirhead, and communication can be kept up to a distance of about 25 miles, (40 kilometres). As the study of wireless telegraphy is going on continuously, it cannot be said that this system will be permanent.

The Line of Communication Telegraph Company.—This company consists of *personnel* sufficient to maintain 100 miles of line and 10 telegraph stations, but does not carry any stores. If there should be no line already laid ready for use, or in other special cases of necessity, the stores are usually sent up from the rear.

All the above is the duty of the Engineers. In addition there is also a telegraph company, formed by the War Office in collaboration with the department* of communications, whose principal work consists of the erection of permanent lines, and the training of telegraphists. I shall not deal with the organization, instruments, stores, etc., here.

The Employment of the Telephone in all Branches.—There is a squad of telephonists in an infantry brigade, an artillery brigade, and a battery of artillery. Details as follows:—

In an Infantry Brigade (4 battalions) there is a telephone section consisting of 2 N.C.O.'s and 15 men. The section has two horses, each carrying six drums containing ½ mile of light telephone wire on its back, whence it can be unreeled directly. There are in all 6 miles, and *personnel* for four stations (telephone).

In an *Artillery Brigade* there is a telephone squad of 13 men, who have one cable cart similar to those used by the telegraph companies. In a *Battery of Artillery* there are two mounted telephonists for keeping up internal communication: they each have one telephone, and carry two rolls of light telephone wire, and also requisite knives, stakes, and signalling flags.

From what I have already said, it will appear that there is a full provision of a network of electrical communications from the main army to the furthest advanced post. In addition to this, very much use is made of signalling. There is both *visual* and *oral* signalling, the former being the method principally used in the Army. I shall refer to it in this article simply as signalling.

There is no special unit in existence for the purpose of signalling communication. Every unit has a certain number of signallers, and there are also signallers attached to brigades and divisions. The approximate numbers in each branch are as follows:—An infantry company has two N.C.O.'s and three men, a cavalry squadron eight N.C.O.'s and men, a

* *i.e.* Post Office.

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battery of artillery and a company of Engineers three N.C.O.'s and men each. There are also a certain number of signallers belonging to regiments and battalions.

There are two methods of signalling, the "Morse" and the "Semaphore." The "Morse" system is the one adopted in ordinary telegraph work and is used with flags only, with the heliograph, and with the signalling lamp. The "Semaphore" system consists of two wooden arms, which according to their position represent letters. Two similarly coloured flags can be used to signal with: and in certain cases one can communicate by using merely the arms. The speed is greater than when using flags in the "Morse" system, but the effective distance is much less. The reason for this is, that when using flags in the "Morse" system, in order to make the dots and dashes, the rapid fluttering of the flags makes them appear to the eye larger than they really are, and consequently they are able to be distinguished at a great distance. Our "Katakana" signalling is on the same principle as the "Semaphore" and therefore does not appear suitable for communicating over long distances.

I will here mention briefly the signalling apparatus used in the English Army. The flags used are of two colours, white and dark blue: the former is used in places with a dark background, and the latter in places with a light background, as on the highest point of rising ground where the flags can be seen against the sky. This is not definitely laid down, as white or blue flags may be used even when the background is of a similar shade; it depends on actual trial, on the presence or absence of the sun, and on the state of the atmosphere, etc. It is very important to choose the right flags to use on different occasions. In our country, when signalling in "Katakana," the system in vogue is to use at the same time both a white flag and a red flag. Should there be occasions when either of these colours are hard to distinguish, there is a fear that communication might not be established. I think that all these points are well worth our study.

The flags are also of two sizes, the larger being 3′ square, and the smaller 2′ square, both sizes are made in the above two colours. ⚬ ⚬ ⚬ In addition to them there is the heliograph and the signalling lamp. ⚬ ⚬ ⚬

The Method of Training the Signallers in the Various Units.—In every unit, it is usual to hold a yearly signalling course, for the purpose of keeping up the establishment of signallers. For the purpose of training them as instructors and assistant instructors respectively, a certain number of officers and N.C.O.'s undergo the course of instruction at the Army Signalling School. As the method of training in units is closely in accordance with that of the Signalling School, it is ensured that the signalling in all units of every branch of the Service is absolutely uniform. The unit commander decides the length of the signalling course, it is usually from three to four months. When once the course is begun, no interruption is allowed, of course those doing the course are excused all duties. A very brief synopsis of the course is appended.

(*a*). The method of forming letters, numerals, and special signs, in both "Morse" and "Semaphore" codes.

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(*b*). The construction, capacity, dissection, assembling, and means of maintenance of all the instruments and materials used in signalling.

(*c*). The duties of a signalling station.

(*d*). The establishment of a network of communication in the field, and signalling exercises.

As the "Morse" symbols must be absolutely committed to memory, during the training from four to eight letters a day is the limit taught, also they are not taught in sequence, but in order of simplicity. At the same time they instruct them with a practice transmitter and a sounder, and make them send and read the letters they have already learnt. From the beginning the speed is 30 words a minute, and at the same time they are taught how to manipulate the flags, how to hold them and how to make the dots and dashes. Special attention is paid to correcting the position of the body. The "Semaphore" is taught at the same time, all the exercises being carried out so as to mutually harmonize. Also the assistant instructors send correct messages either with the flags or the heliograph, and the men are accustomed in reading them. In this way they are enabled in about two weeks to send and receive messages over short distances. In these exercises those under instruction are divided into two parties each consisting of two men, they are placed facing each other and alternately send and receive. ° ° ° Later the duties of signal stations are taught and also the methods of arranging for a connecting, or intermediate, station. Finally signalling manœuvres are carried out, and at the end of the course there is an examination. Those who qualify are designated "Signallers," wear a special badge, and receive additional pay.

Once every year the signallers of all units are inspected, this inspection being both individual and collective. In the individual inspection the ability of each man is determined and if he does not come up to the requisite standard he at once ceases to be a "Signaller." The standard is different according to the instrument used, but they must obtain at least 95 per cent. marks in both sending and receiving 40 words a minute. In the collective inspection, the instructors, assistant instructors, and signallers of the regiment or battalion are collected, and they are required to organize a network of communication according to some tactical scheme, this tests their practical efficiency.

The Signalling School.—The object of instructing officers and N.C.O.'s is to make them instructors and assistant instructors of signalling. As the system of army signalling is universal throughout the whole service, officers and N.C.O.'s are sent from all branches to form the classes. The period of instruction lasts about two months, and new classes are assembled about five times a year. The *personnel* of each class consists of about 30 officers and N.C.O.'s, chosen by their unit commander. Before entering the school they must already be able to signal at the rate of 30 words a minute, they are all men of ability and having a general knowledge of signalling. At the end of the course there is an examination, and a certificate is given to those who pass. During these two months the students are very much occupied with various exercises all day, and practise with the signalling lamp in the evenings. As there is practically

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no day of leisure, by the time they pass out their skill has reached a very high standard.

Occasions for the Use of Signalling Communication.—In fortress warfare, and of course in field fighting, the occasions when one can use signalling as a means of communication with advantage, are numerous. For instance, in all kinds of attack and defence, to establish connection between the commander and the various detachments, between the outpost line and the troops in rear, between troops on the march and the advanced, and flank, guard; and between the cavalry, the reconnoitring parties, and the main body. In the English Army, both at field exercises, and at manœuvres, very great practical use is made of signalling in addition to the telegraph and the telephone. From what one has heard from senior officers who have been in Europe, signalling is not used anywhere like it is in the English Army. The truth is that English officers realize the value of signalling as a means of communication, and the excellence of their method, and the ability and training of their signallers, makes them confident that they are (in this respect) superior to all other armies. For which reason the attention paid to signalling as a means of communication is very great.

Conclusion.—During a campaign, the leadership and co-operation of the armies depend on the service of communication, and it is unnecessary to insist that victories and defeats depend directly on the good or bad quality of this service. Of all means of communication adopted in the Army, electrical methods are the most important. The development of art, and the advance of technical manufactures, in recent times, has more and more tended to the ingenuity of the instruments; but in proportion to the fineness of their mechanism the slightest defect makes them very liable to lose their efficiency. Further, a hitch would be often likely to occur on the battlefield, or, owing to an accident happening at a critical time it is quite possible that a valuable opportunity might be lost. For which reason it is very essential that some alternative method should be studied. Also, there are naturally limits to the establishment of electrical communication, and one cannot hope to make use of it on every occasion and in every place. For these times, it is extremely advantageous to practise an alternative method, and, with the exception of signalling there is nothing that satisfies all the conditions. In our Army it has always been considered that the signalling—for example "Katakana" signalling with flags—has given very inaccurate results, the reasons being an inadequate study of the method and imperfections in the training. When excessive demands have been made on the system and the results have not come up to expectations, has one not lost confidence in it? For if the fault did not lay with the system, then it must have lain with those who were making use of the system. Signalling as a means of communication is certainly not such an inaccurate matter as that. The following true incident will show how far one may depend on it:—Once, from the Northern Frontier of India, a very important message consisting of about 1,500 words was despatched, and after passing through several signal stations manned by native soldiers, was telegraphed on and reached London in six hours with only two mistakes.

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These native soldiers did not speak English, and had merely been instructed in the English signalling method. If one is able to achieve such a result as this, it follows that, if the method of instruction be good, the prestige of signalling as a means of communication would be greatly enhanced. Such a result would be impossible if the important points of signalling are merely explained; actual practice must be made of the first importance, or else good results cannot be expected.

Although I have only spoken in a general way about signalling as a means of communication, yet I think you will be able to appreciate its utility. But the development of electrical communications has been so remarkable, that one has been blinded by their glamour, and the present state of the case is that methods of communication like signalling have been almost discarded. Also it cannot be said that electrical communications are absolutely perfect and even for military purposes there are occasions when they cannot be depended upon. Therefore I believe that the comparatively simpler methods of signalling should never be discarded, and I also think that there is room for much further study, although unfortunately it is admitted here that signalling is treated almost as if it were an obsolete system. o o o o

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CORRESPONDENCE.

RESISTANCE AND "DRIFT" OF A BULLET.

SIR,

Will you allow a mere student to state some accepted facts as regards air resistance and drift.

Twenty-five formulæ, more or less of the type proposed by Colonel de Villamil for air resistance, are in existence. He gives reasons for claiming that his formula is not simply empirical. But he will admit (1) that his formula takes no account of the air carried with the bullet, (2) that whatever may be his meaning in saying that when the velocity of the bullet exceeds that of sound "the potential energy of the air is exhausted," the bullet still generates sound waves—only instead of the train of sound waves preceding the bullet they follow it.

As regards drift.

The greatest living authority on theoretical ballistics—an Englishman whose name is less known in England than in Germany, Russia, France, America or Japan—speaks of drift as "an obscure issue by gravity out of curvature of the trajectory."

There are four factors recognizable. (1), Precessional couple due to air resistance; (2), rolling of the shell on the cushion of compressed air in front of it; (3), excess of lateral thrust—due to the rotatory motion being with the air current on one side, against it on the other; (4), vibratory effects.

But the one thing that appears quite clear is that we want more light on the *facts*. For instance little is known even of the rate at which a shell loses "spin." Little is known of the true exact nature of the vibratory movements in the gun during firing.

It is generally regarded as an established fact that the nose of the shell is a little *above* the tangent to the trajectory. Has Colonel de Villamil any experimental evidence to refute this conclusion which is based on experiment?

Is it not possible that the cinematograph may throw light on these and other questions? (See *Cranz. Ballistik*, Vol. 4).

I am,

Yours faithfully,

C. S. JACKSON.

R.M. Academy, Woolwich.

The Editor, *R.E. Journal.*

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THE "DRIFT" OF A BULLET.

DEAR SIR,

As there appears to be sufficient talent engaged already I do not propose to take part in the general discussion, although I must confess myself an uncompromising supporter of the text-book theory. I desire, however, to join issue with two of your correspondents on a matter of *fact*.

Capt. Carey says "As regards drift being caused by gyroscopic action. . . . The only drawback to it is that the bullet happens to drift in the wrong direction to suit this theory."

Lieut.-Colonel de Villamil says:—"Crabtree's explanation I cannot follow. He says referring to the hand gun (page 53):—

"(1). Spin of bullet is left handed.

"(2). Nose of bullet is above trajectory.

"(3). Wind pressure on the underside of the nose end *tends* to tilt the point upwards, but

"(4). Results instead, owing to gyroscopic action, in the bullet working over slightly *to the left*.

"An experiment with a small gyroscopic top suspended, as shown, should convince anyone that the result is *exactly the reverse*."

I have been acquainted for some years with the mathematical theory of the gyroscope and its application to the theory of the rifle bullet, but it never occurred to me before that the theory might not agree with experiment. I therefore borrowed a small gyroscope from Mr. L. Brennan (for whose kindness I tender my sincere thanks), and carried out the following experiment:—

Gyroscope rotated so as to represent bullet with left-handed twist (counter-clockwise viewed from behind). Upward pressure applied to the nose.

Result, nose deflected to the left.

I may add that a very clear and ingenious method of determining the direction of the precession is to be found in Mr. F. W. Lanchester's book on *Aerial Flight*, Part II., Aerodonetics, Appendix VII., and there is also a discussion of the rifle bullet in Appendix VIII*a*.

Yours faithfully,

K. E. EDGEWORTH,
Capt., R.E.

Chatham, 9th April.

THE EDITOR, *R.E. Journal*.

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RECENT DEVELOPMENTS IN TELEGRAPHY AND TELEPHONY.

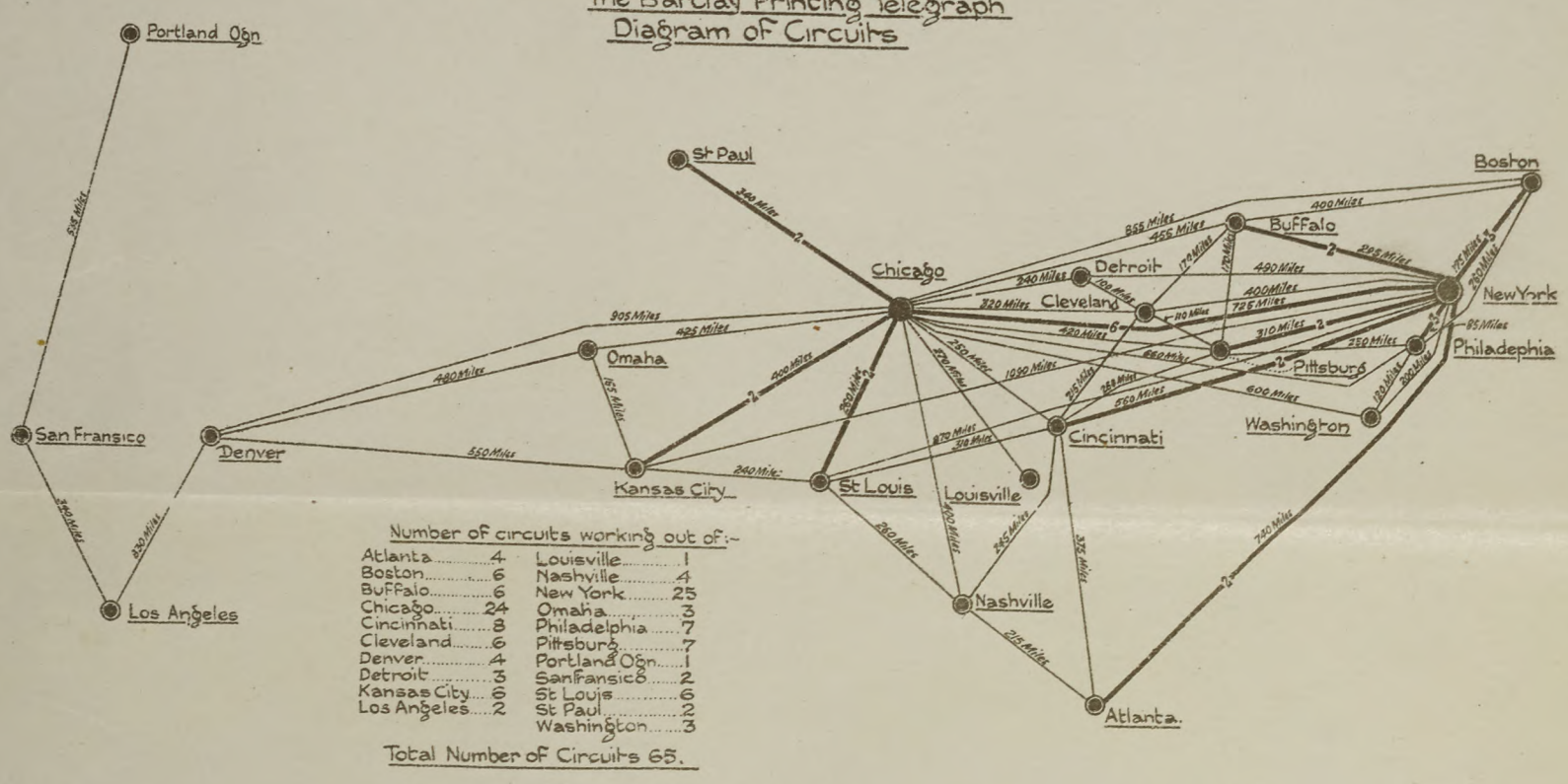
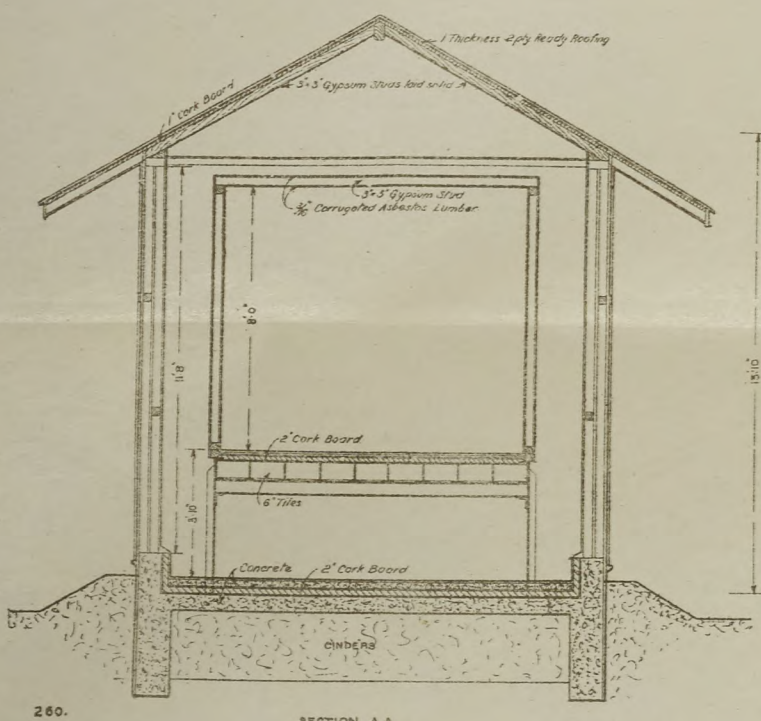


FIG. 1.



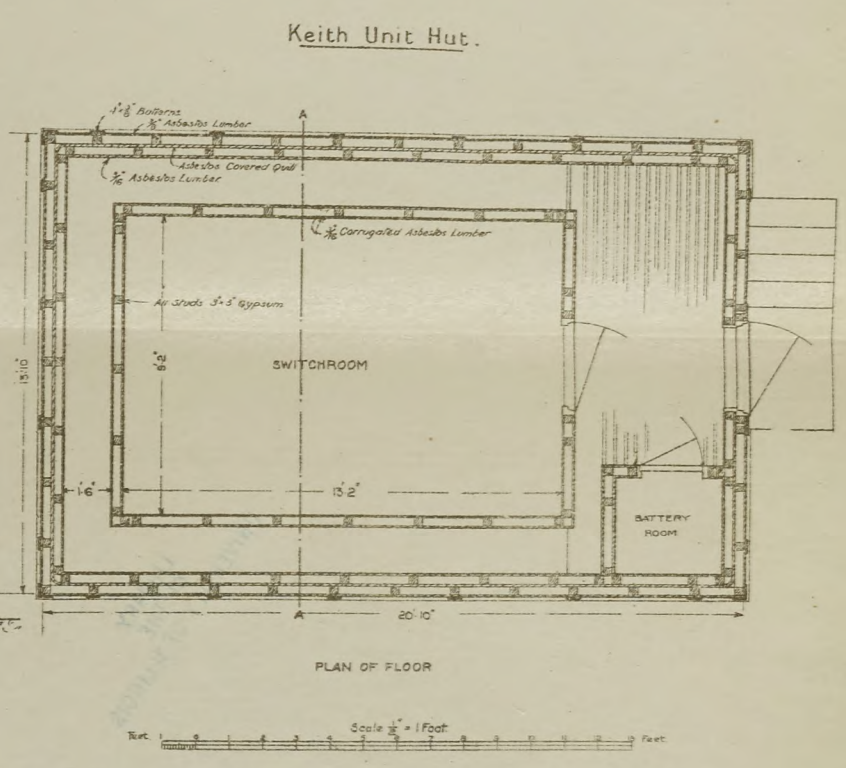


FIG. 2.

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SOME EXPERIMENTS IN THE DESTRUCTION OF DEFECTIVE POM-POM AMMUNITION.

Photo 1.

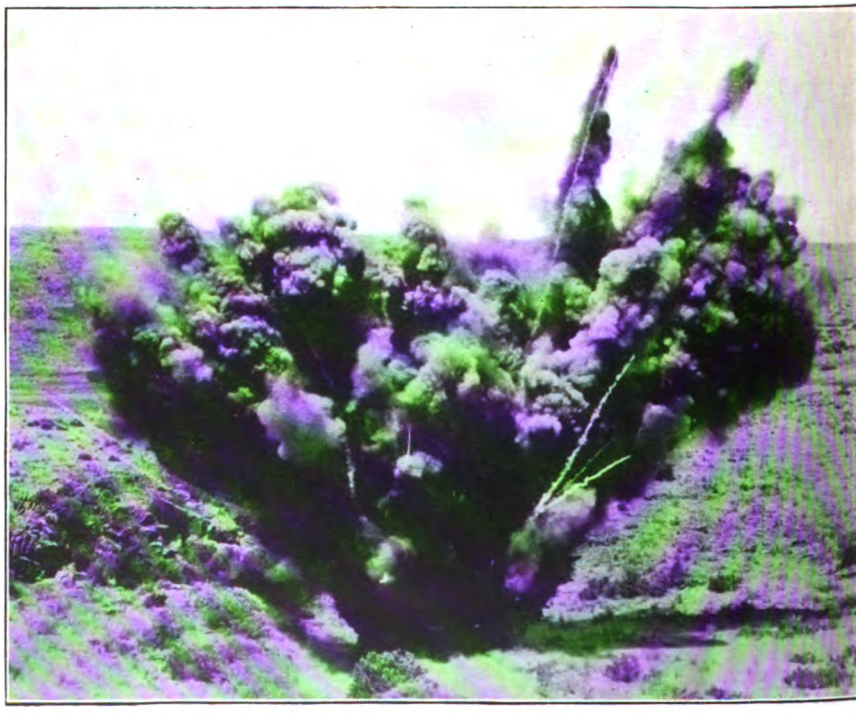

Photo 2

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REPORT ON SOME EXPERIMENTS IN THE DESTRUCTION OF DEFECTIVE POM-POM AMMUNITION.

By Capt. P. S. Greig, R.E.

Orders having been received to destroy, in the best way possible, a considerable number of rounds of defective pom-pom ammunition, the following experiments were carried out by the writer and an Ordnance officer, assisted by some N.C.O.'s. As the results were not a little instructive (as well as exciting) and may be of interest to others, a detailed account is given herewith :—

Experiment No. 1.—The ammunition is packed in wooden boxes of 80 rounds each. To avoid the trouble of having to open each box, our first endeavour (which was purely tentative as we had no idea of what the result would be) was to try the effect of a half slab of guncotton placed on the outside of the box, which was placed on its side in a rocky donga.

Details.—Charge = half slab of guncotton with 1 oz. guncotton primer and 5′ of safety fuze, placed on outside of box and tamped with four sandbags on top and four at sides of box.

Result.—The result was not a success. The ammunition was found in every stage, some quite intact, some cartridge cases blown to bits, some full or partially full of unexploded cordite, others with unexploded caps and no cordite. As far as could be ascertained none of the shells had been broken, and they were lying about probably in a "live" condition, *i.e.*, the shells were liable to explode if dropped.

The lesson to be learnt was the necessity of destroying the "shell end" of the ammunition, and letting the cartridge cases (with their cordite contents) join in the *mêlée* if they would.

Experiment No. 2.—In this experiment quite a different procedure was adopted. The ammunition was taken out of the cases and laid nose to nose in rows on the rocky bed of a donga, first two rows of 50, then four half slabs of guncotton laid touching each other down the centre, so that the guncotton was in contact with the shells, then two more rows of 50 rounds each, the whole being tamped with six sandbags and stones, and on the top of everything a large bundle of wire netting about 10′ long and 4′ in diameter, used for blasting purposes.

Result.—The result was very successful ; on the rocky bed of the donga where the explosion took place, nothing was to be seen.

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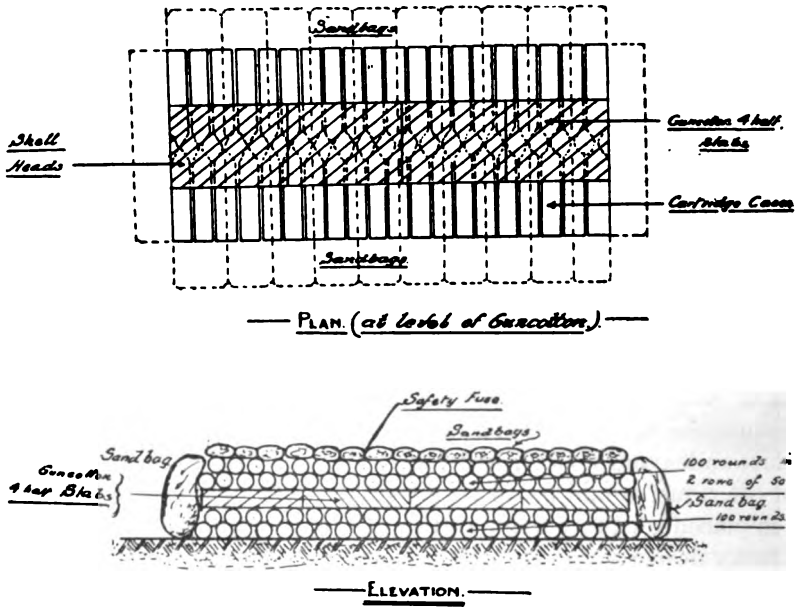
Some minute portions of cartridge cases, found in the vicinity, pointed to the complete detonation of the cordite, while the absence of any shells indicated that the object in view had been obtained *i.e.* the breaking up of the "shell ends" of the ammunition.



This method, though altogether successful, was very expensive in guncotton, *i.e.* two slabs had only destroyed 200 rounds (necessitating, at the same rate, a very large number of slabs for the total amount awaiting destruction).

Experiment No. 3.—In the next experiment therefore the number of rows of ammunition was increased to six, with about 28 rounds in a row *i.e.* a total of two boxes. In addition two complete *unopened* boxes, were placed one each side of the pile (see *Photo* 1).

The charge of guncotton, two and a-half slabs in this case, was placed on the top of the rows, the whole being tamped with 10 sandbags and a bundle of wire 10′ × 4′. The guncotton primer was placed in the centre slab with 5′ of safety fuze.

We watched the result from the shelter of a sangar on the top of a neighbouring kopje, about ¼ mile away.

Result.—The result was a tremendous explosion. The coil of wire was carried aloft on the crest of a dense column of smoke to a height of about 200′—a fine spectacle! Shells however whistled in all directions and five distinct explosions took place, the most distant being some 500 yards from the scene of the charge. This was probably due to the two unopened boxes, which it was hoped would be destroyed in the general conflagration.

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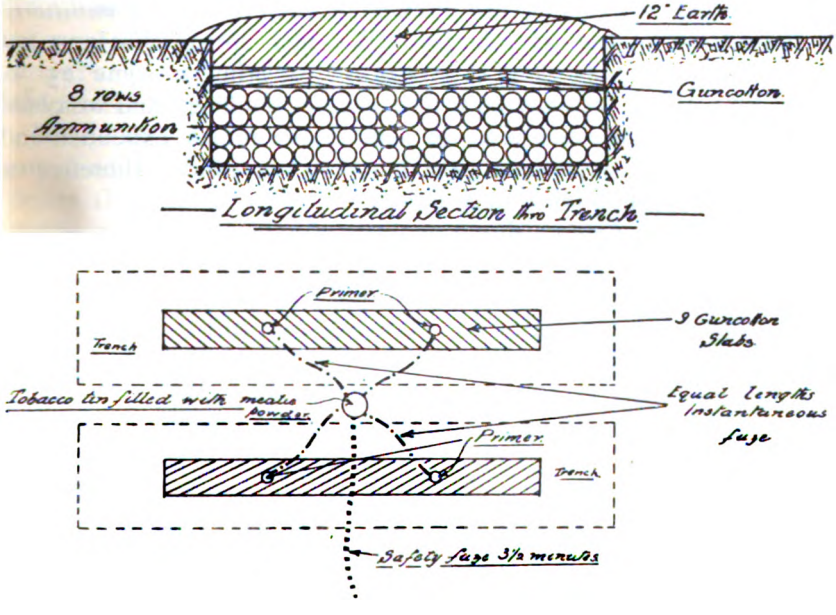
As in the previous experiment, nothing was to be found in the immediate vicinity of the charge, but several live shell heads, lying about among the rocks, showed plainly that the right solution had not yet been arrived at.

Experiment No. 4.—In this experiment we decided to discard the wire netting (which merely made aerial voyages and did nothing in the way of confining the splinters) and to place the ammunition in trenches, so as to localize the effect of the explosion and create a crater in which subsequent charges might be placed.

Two trenches were accordingly dug about 12″ apart (each being 15″ wide and 9′ long and about 2′ 6″ deep), in which eight rows of ammunition were stacked "nose to nose" as before.

The charge (per trench of 760 rounds) consisted of nine slabs of guncotton, cut in halves, and placed against the shell heads, the whole being tamped with 12″ earth. Nineteen boxes of ammunition, *i.e.*, 1,520 rounds altogether, were placed in the trenches.



The above diagram shows arrangements for firing the charge.

Everything being prepared, we sent the natives to the shelter of a neighbouring farm, while we betook ourselves to our eyrie on the hill, (some 200′ above the donga and ¼ mile from the charge) where we had previously taken the precaution of providing some head cover of two sheets of corrugated iron over the sangar.

The explosion was very fine. I had just looked over the parapet and pressed the bulb of my camera, when a cry of "look out" reached me from my next-door companion. At the same time a

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shell burst on our right flank and a large splinter struck the roof of our shelter fairly in the middle, fortunately without penetrating the corrugated iron.

The air was alive with things whistling and rotating and obeying various centrifugal, centripetal and other compelling forces, but from our coign of vantage we only saw one other shell actually burst.

The owner of the neighbouring farm (about ½ mile distant) told us afterwards, that he had seen five shells burst; one alighted on the roof of his stable (but did not penetrate) while the native boy inside nearly died of fright, thinking every moment was going to be his last. One unexploded round (cartridge case and shell) was found near the farm, giving some idea of the force of the explosion.

Result.—In the crater (17′ × 14′ × 5′ deep, which elicited many "waghs" of astonishment from the natives), a number of unexploded rounds were found, in some of which the shell had been driven 3″ into the cartridge case without exploding. A certain number of unexploded shells were also to be seen lying about in the vicinity.

At this stage we gave up the problem of any efficient "*demolition*," or detonation of the ammunition. We had spent two long hot mornings, used up 23 slabs of guncotton, 7 primers, some 25′ of safety fuze, 16′ of instantaneous fuze, several sandbags, and we could only point, on the asset side, to some 1,968 rounds expended and certain amount of experience gained, and it was decided therefore to discontinue this method of destruction.

Accompanying *Photo 2* shows explosion No. 4.

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DEMOLITION OF GIRDERS.

By MAJOR J. C. MATHESON, R.E.

THE present textbook gives directions how to calculate the charge of guncotton required to demolish a girder, and extensive trials have proved their correctness. They involve, however, the measurement of the section of the girder, and it is not difficult to conceive of cases when this would be a dangerous or even an impossible task, to say nothing of the time it would always take to do. On active service bridges may, and will, have to be destroyed by night and in as short a time as possible. In all probability no calculations would be done in such a case, the officer carrying out the demolition would on arrival at the bridge hastily glance at it, guess at the charge and then add a large percentage of explosive in order to avoid failure.

But it may be necessary to study economy of explosives, and in any case it would certainly ease the mind of the aforesaid officer before the explosion, if there were some simple expression for the charge which required the minimum of measurement and arithmetic.

According to the textbook directions, the charge required depends upon the breadth and thickness of the various parts which go to make up the girder. But the section of the girder according to type depends upon the span, the depth, and the load it has to carry. Therefore the charge should be some function of these factors. The general form of this expression has been found to be

$$\text{charge} = \frac{LW}{kD} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where L = span of girder in feet
W = breaking weight in tons
D = depth in feet
k = a coefficient.

In almost every case L and D can easily be measured, or a fairly accurate approximation to them can be made. The coefficient k depends upon the type of girder, and values can be obtained for it by equating to the charge, as worked out by the textbook method, once the breaking weight is known. This latter however cannot be deter-

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mined by inspection and it is impossible to give a value which will include all cases, but, by making certain assumptions, it is possible to give a value to W which will include a fair range of the ordinary type of girder bridges, and the expression (1) will then give results of sufficient accuracy. It must always be remembered that we are not dealing with an exact science, what is aimed at is to arrive at a charge which will cut the girder with certainty and without undue expenditure of guncotton.

Girder bridges are met with mostly on railways, and one of the most usual types is the plate girder for small spans.

To obtain the required expression for girders of this type the following are the assumed data :—

Spans, from 20′ to 80′ of 4′ 8½″ gauge.
Load, 2·67 tons per foot-run of single line.
Factor of safety, 8.
Charge, expressed in service slabs of guncotton ("guncotton, wet, slabs, field, 15-oz."), including the allowance of 50 per cent. for the presence of the enemy.

On the above assumptions the general expression (1) becomes

$$\frac{L^2}{15D} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

This will give the charge necessary for each of the two girders and it must be placed near an abutment, being divided up and fixed to the girder in the manner described in the textbook.

Where one girder has to bear the whole load of a line of railway, *e.g.* two girders carrying a double line, or a central girder carrying half of two single lines, the amount given by expression (2) should be doubled. This will however give rather more than the necessary charge.

For spans between 80′ and 200′, fairly accurate results are obtained from the expression

$$\frac{L^2}{24D} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Expressions (2) and (3) are primarily intended for plate girders but they may also be used for lattice and box girders with a fair amount of accuracy, the results given being generally more than the textbook charge.

The accuracy of these expressions may be judged from the following table which gives instances of existing bridges or of girders of requisite strength taken from catalogues :—

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Girder.		Span in feet.	Textbook Charge in Slabs + 50 per cent.	$\frac{L^2}{15D}$ or $\frac{L^2}{24D}$ according to span, doubled if necessary.	Remarks.
Plate.	Single line ...	30	21	20	Example M.E. Part IV.
,,	,, ...	24	18	16	From Dorman Long's Catalogue. Depths of girders vary.
,,	,, ...	28	18	18	
,,	,, ...	30	26	24	
,,	,, ...	32	23	23	
,,	,, ...	40	30	27	
,,	,, ...	40	21	21	S.E.C. Railway.
,,	Centre of two lines	40	40	42	
,,	Double line ..	46	45	62	,,
,,	Single line ...	56	42	42	,,
,,	,, ...	170	84	81	S.E.C. Railway, Medway bridge.
,,	Centre of two lines	170	149	160	
,,	Single line ...	100	55	53	C.P. Railway.
,,	,, ...	55	35	36	Caledonian Ry.
Lattice.	Single line ...	50	18	21	From Bridge Manual.
,,	Double line ...	120	83	80	S.E.C. Railway, Medway bridge.
,,	,, ...	144	91	115	
,,	,, ...	171	102	162	
Box.	Single line ...	28	17	21	From Dorman Long's Catalogue.
,,	,, ..	46	31	36	
,,	,, ...	56	49	53	

For railways of other than standard gauge the charge will vary in proportion to the gauge.

The application of an expression of this kind to girder road bridges

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is a more difficult task on account of the varying loads which these bridges are built to carry. For first-class road bridges, up to 50′ span, carrying such traffic as traction engines, the following expression may not be very far wrong :—

$$\frac{BL^2}{160 \times nD} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where B = breadth of bridge in feet
L = span in feet
n = number of girders
D = depth of girders in feet.

It is true that this expression requires some arithmetic in working, but the measurements can all be taken very quickly. The results given by (4) in the case of three bridges were :—

(*a*). Textbook charge 19 slabs, expression 27.
(*b*). „ „ 32 „ „ 30.
(*c*). „ „ 11 „ „ 14.

As it has been somewhat difficult to find examples of this type of bridge which permitted of proper measurement, possibly some officers in other places may find time and opportunity to check the accuracy of the expression.

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SOME RECENT DEVELOPMENTS IN THE DESIGN AND CONSTRUCTION OF EARTHEN DAMS.

By CAPT. A. FF. GARRETT, R.E.

CONSIDERABLE attention has been devoted in India during the past 10 or 15 years to the theory and construction of earthen dams for impounding reservoirs, and it seems desirable to put on record the experience gained, especially as no comprehensive account of recent developments appears to have yet been published. Earthen dams have been built in India by the thousand from time immemorial. There are said to be over 40,000 in the Central Provinces alone, and there are countless numbers in the Madras Presidency, and many more in Rajputana and Bombay. Most of these are small village tanks with catchment areas of a few acres only, but on the other hand there are several native dams of quite large dimensions, holding up sometimes as much as 3 or 4 square miles of water. The large majority of these native tanks have been built for purposes of storing the monsoon rainfall for irrigation; many of the smaller ones are used as sources of water supply for drinking purposes by the villages near to which they are situated, whilst a few of the larger ones in Rajputana seem to have been constructed chiefly as pleasure lakes by rajas of a bygone day. There is little or nothing to be gained by a study of these native tanks. There is no evidence of scientific design. The cross sections of the dams of the larger and successful works are usually exceedingly heavy, while numbers of the smaller works are breached every year. It is, however, only comparatively lately that earthen dam construction has been taken up on a considerable scale by Government, and the subject scientifically studied. Two important principles, profoundly affecting the design of earthen dams and reservoirs, have recently been enquired into. The first of these is the investigation of the line of hydraulic saturation in a dam, and the second is the evolution of formulæ to allow, in calculating the waste weir, for the temporary storage of flood water between the full supply level of tank and the high flood level. The first affords for the first time a criterion by which the sufficiency of the cross section of an earthen dam may be judged, while the second has led to a far more correct appreciation of the true principles on which the waste weir should be designed, and has resulted in the saving of large sums of money.

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In this paper it is proposed to deal with :—

I. The design of the cross section of an earthen dam, giving examples of successful practice in India, and a brief account of the recent experiments on the line of hydraulic saturation.

II. The design of the waste weir with an account of the recent flood storage formulæ.

III. Other miscellaneous matters in connection with the subject.

I.—THE DESIGN OF AN EARTHEN DAM.

An earthen dam may fail in four ways :—

(1). The earth may be cut away, or scoured by wave action, and the dam breached.

(2). An excessively high flood may cause the water level to rise over the top of the embankment.

(3). Water may percolate through a hole in the bank, and gradually enlarge the passage until the work fails.

(4). The earth work of the dam may slip, or it may subside or settle down.

Failures under (1) are prevented by protecting the inner slope. The cheapest method is usually to provide dry stone pitching from 9″ to 12″ thick, but, on a well-consolidated bank, concrete is sometimes used. The latter practice is, however, somewhat risky as any slight settlement in the bank will cause bad cracks in the concrete. For low banks, branches of trees well pegged down afford a good though temporary protection. In the case of small works, where the prevailing winds blow away from the dam and the earth is fairly good, no protection at all may be necessary.

In laying pitching certain precautions are necessary. If the dam will be exposed to strong winds blowing over a considerable area of the impounded water, waves will be generated which will tend to wash out the earth between the joints of the pitching, which will then subside and may cause a failure of the work. It is therefore most necessary that the joints of the pitching should be kept as close as possible, especially at the under side where the stones rest on the earthwork. If, as is often the case, the stone be of such a character as not to admit of close joints being easily made by a simple hammer dressing, it is advisable to lay down a 3″ or 4″ layer of coarse gravel or stone chips between the earthwork and the pitching. If the earth tends to be washed out by wave action, the dam will give constant

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trouble, and it is well worth while to spend a little more money to begin with to avoid all risk of such difficulties afterwards. The pitching may be left quite rough on the face. This may not look very neat, but it tends to break up waves, and is therefore rather an advantage than otherwise.

Failures under (2) can of course only occur from inadequate waste weir provision, or a bad subsidence of the earthwork.

Failures under (3) are not very uncommon. Holes may be left in the bank owing to faulty supervision during construction. If large clods are allowed in a bank, there will be interstices through which water may percolate and so cause failure. An instance of this came under the writer's notice about three years ago. The bank about 35′ high had been somewhat hurriedly constructed during the hot dry weather. The earth was a clayey loam and had been baked excessively hard by the Indian sun, and the labour of breaking clods was therefore heavy. In fact it was almost impossible to secure thorough consolidation even by repeated rolling. On the bursting of the monsoon the reservoir filled up to about 10′, and the work then failed from percolation. It was stated that the water could be actually heard gurgling through the bank. An examination of the cross section of the dam subsequently showed that although there were very few clods over the specified size of 3″, yet there were numerous interstices between the smaller clods. Holes may also be formed in the bank by the burrowing of rats and other animals, or by the decaying of roots of trees. For this reason trees are not allowed to grow on the banks. If the bank is built of a clayey soil, large cracks may be found in hot dry weather through which water may percolate and cause failure. For this reason some authorities—*e.g.* Fanning—object to puddle altogether in the embankment, and prefer a mixture of clay, sand and fine gravel. Yet another way in which percolation may occur is by creeping along the junctions of earthwork and masonry. At these places it is necessary to take the usual precaution—to leave the back of the masonry as rough as possible, and to ram the earth tightly against it—and to provide staunching or creep walls at intervals.

The consolidation of the earth is a most important matter. In English practice it is usual to rely entirely on the puddle core to prevent percolation, and no special precautions are taken about the consolidation of the rest of the earthwork. Where puddle of as excellent a quality as is obtained in England is available, this method gives very good results, but in other parts of the world it often happens that no such first-class puddle clay can be obtained, and it thus becomes necessary to provide not merely a puddle core, but a substantial hearting of the best clayey material available. Also in tropical countries there is a risk of a puddle core becoming dry and

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cracking, and it is therefore better to provide a more massive hearting of a somewhat less clayey material, and to restrict the use of puddle to portions of work lying below the ground where moisture will be better retained. In parts of India the system has been tried of constructing the whole dam of clay, but recent experience has shown that this is a great mistake as will be mentioned below. Assuming then that a substantial hearting of clay is to be adopted, the object is to secure as thorough a consolidation as possible into one homogeneous mass. It is usually specified that no clods over a certain size, say 3", are to be allowed in the bank, that the earth is to be laid in 6" layers sloping slightly inwards, and that each layer is to be thoroughly rolled or rammed until well consolidated. It is a disputed point as to whether it is desirable to water the earthwork or not. On the one hand it is claimed that wetting the earth softens it and secures better union between clod and clod, while some authorities state that, as earth expands when wetted, it is much better to construct the bank dry, so that, when it is eventually wetted by rain or by the filling of the reservoir, the earth will expand and a much more solid bank will be obtained than if it were originally constructed of damp earth. For low dams, not holding up more than 25' of water, experience shows that watering is usually unnecessary, but the whole matter is merely one of proper consolidation and prevention of percolation. No interstices must be left through which water can percolate. This condition can be secured either by thorough rolling when the earth is in a damp and plastic condition, or by breaking up the earth into small lumps not exceeding 1" in diameter and rolling dry. It has even been proposed to lay puddle in the form of dry powdered clay well rammed. This would probably be very effective, and would form a very dense and compact mass of clay when wetted, but the expense of so finely dividing the dry clay before laying would generally be heavy. The consolidation must be frequently tested during construction by digging into and examining the newly-erected earth, and that amount of watering and clod breaking carried out, which actual experience of the particular earth being used shows to give the best consolidation. It is dangerous to use a very clayey earth dry, as such material forms hard lumps which it is almost impossible to consolidate even by heavy rolling. On the other hand a more loamy earth, even when dry, is more or less friable, and can often be closely consolidated by rolling. In any case it is not advisable to raise the bank more than about 30' in one year, so as to allow the rain to penetrate the whole bank, and so help to consolidate the lower portions of the work before raising the dam to the full height. It is stated that better consolidation can be obtained by driving laden carts over the earthwork than by ordinary rolling, and an American writer recommends that diagonal bands be fixed on the

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rollers. A 6 or 8-ton steam roller is very useful for large banks. Too much care cannot be taken in the proper consolidation of the lower layers of a big earth dam, and numerous are the failures which have occurred from percolation. All earthen banks settle more or less when the reservoir fills with water, however much care may be taken over the consolidation, and it is necessary to allow for this during construction by making up the bank to a higher level; an allowance of 1″ to 1½″ per foot of height is usually sufficient.

Failures under (4), due to slips, require more detailed examination, and it is along these lines that recent investigations have been made. Long practical experience has shown that a section under certain dimensions is liable to slip, and most of the textbooks lay down that the front or water slope should be about 3 to 1, and the back or outer slope 2 to 1.

The top width, they state, should be 6′ for a small dam, up to 10′, 12′ or 15′ for larger works. In all earth banks, a danger to be guarded against is a slip of the earthwork, and as the angle of repose of wet earth is less than that of dry earth, it has been the usual practice to make the inner slope, which is necessarily saturated when the reservoir is full, flatter than the outer slope. It has, however, been recognized that for high earth dams, to hold up say over 25′ of water, this section is inadequate, and either horizontal berms have been added on the back slope, or the slope itself has been flattened in an arbitrary manner, see *Fig.* 1, which is taken from Colonel Scott-Moncrieff's *Water Supply of Barracks and Cantonments.* Recently, however, a considerable advance has been made. Mr. Hill, Chief Engineer in the Bombay Presidency, took up the investigation of a number of slips which had occurred on the back slopes of several reservoirs in the Bombay Presidency, and the results of his enquiries are to be found in paper No. 17 of the Irrigation Conference, Simla, 1904, and also in a Bombay technical paper published by him in 1909.

The method of investigation adopted was to sink a series of pipes along a cross section of the dam, and then ascertain the height to which water rose in these pipes. It is evident that below the water level in the pipes, the earthwork in the dam must be completely saturated. Joining the water level in the various pipes by a line, the line of hydraulic saturation in any given dam is obtained. In *Fig.* 2, which is a cross section of the Mukti tank dam, the position of six such pipes is shown, and the line of hydraulic saturation is shown in a thick chain-dotted line. The straight line joining the maximum water level inside the dam with the outer toe of the dam, is the "hydraulic gradient" and can be easily followed. Mr. Hill found that in all cases where slips occurred the hydraulic gradient was steeper than 1 in 4. When it was flatter than 1 in 4 there were no slips.

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Mr. Hill gives the following list of reservoirs in which slips have been observed :—

Name of Work.	Depth of Water below Crest.	Hydraulic Gradient.
Waghad	83	2·7 to 1
Nhasvad	67	3 „ 1
Nehr	60	3·00 „ 1
Ekruk	58	3·48 „ 1
Ashti	50	3·09 „ 1
Bhadalvaldi	44	3·50 „ 1
Shirsuphal	43	2·70 „ 1
Pashan	40	3·4 „ 1
—	43	3·1 „ 1
Matoba	39	3 4 „ 1

Of these, the first five slipped badly while the last five slipped at the outer toe. Mr. Hill continues "The slips at these banks seem to show that the limiting height for safety for the cross section adopted had been decidedly exceeded for the banks with 50′ depth or over, and just passed for depth of about 40′. When suitable berms are added at the rear of these 40′ depth banks, the slipping is stopped. The addition of the berms reduces the hydraulic gradient to about 1 in 4. In addition to this Indian experience, valuable information is available in the report of the Board of Engineers in America appointed to consider the proposal that part of the Croton Dam should be of earthwork. The Board took observations of the saturation of the earth of six earthen dams from 50′ to 90′ total height and found as follows :—

That the embankments were always completely saturated as far as the puddle wall; that moisture passed through the puddle wall with a loss of head of about 10′; that the line of saturation to the rear of the puddle wall varied with the material; when watertight the slope was 35 per cent., or about 3 to 1, and, where very porous, 10 per cent. or 10 to 1. They deduce from their observations that, with carefully selected material, a drop of 17 per cent. of the head in the reservoir may be expected at the puddle wall, and a slope saturation of 23 per cent., or 5 to 1 in the rear of the bank."

Mr. Hill's final conclusion is that it is not safe to construct a high earthen dam of clayey materials alone, but the full significance of the results of his investigations seems to be hardly yet appreciated. In the table below, ten of the principal Bombay tanks have been arranged in order of their clayeyness—so to speak. Thus the dams of the first five tanks consist entirely of clay. The hydraulic gradient varies from 5 to 1 to 2·7 to 1. It will be seen that all these banks slipped except No. 3, in which the hydraulic gradient was 5 to 1. The case of No. 5 is interesting, as the water level was gradually

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Number.	Name of Dam.	Nature of Bank.	Front Slope.	Rear Slope.	Depth below Weir Crest.	Hydraulic Gradient.	Remarks.
1	Waghad ..	Entirely clay, bank all like good puddle.	—	—	83	2·7 to 1	Slipped badly, extensive repairs with large masses of dry stone drains were executed.
2	Nehr.....	Entirely clay.....	3 to 1	2 to 1	60	3 ,, 1	Slipped badly and a berm was added.
3	Wadshivne	Entirely clay mixture, 2 black soil and 1 moorum in centre, 1 moorum and 1½ black soil in casing.	3 ,, 1	2 ,, 1	39	5 ,, 1	Has apparently given no trouble.
4	Matoba	Uniform clay.....	3 ,, 1	1½ ,, 1	39	3·4 ,, 1	Slipped slightly at the outer toe.
5	Pashan	Mostly clay with puddle wall.....	3 ,, 1	2 ,, 1	40	3·4 ,, 1	Depth stored was increased until a slip occurred in downstream toe, which was then strengthened.
6	Mhaswad ...	Selected clayey earth hearting—mixture of earth and casing.	3 ,, 1	2 ,, 1	67	3 ,, 1	Slipped badly.
7	Mayni	Selected earth and moorum on well-drained moorum foundations.	3 ,, 1	2 ,, 1	42	5 ,, 1	— —
8	Unkal	Upper side and hearting of clay downstream side good drainage material.	3 ,, 1	2 ,, 1	42	3·5 ,, 1	Constructed in 1893 and has given no trouble.
9	Mukti	Selected earth hearting slopes 1 to 1 moorum outside.	2½ ,, 1	2·13 to 1	55	2·8 ,, 1	One of the best banks in the Deccan and has never given trouble.
10	Parsul	Retentive clay hearting slope 1½ to 1 moorum outside. Dry stone drain extending well into bank.	3 ,, 1	2 to 1	53	3 ,, 1	Has given no trouble—drainage is very complete.

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raised until a slip occurred, with a hydraulic gradient of 3·4 to 1. This is, however, not a very high dam, the maximum depth of water being only 40′. It is therefore quite clear, as pointed out by Mr. Hill, that it will not be safe to construct any high dam entirely of clayey material, unless the hydraulic gradient is at least 4 to 1. But an examination of the statistics for tanks Nos. 8, 9 and 10 shows that with porous backing and effective drainage arrangements, high dams may be safely built with hydraulic gradients as steep as, or even steeper than, 3 to 1. The case of No. 9 is particularly striking. The bank consists of a selected clayey earth hearting with 1 to 1 slopes, and moorum outside (moorum is a very porous red gravelly earth). This dam is said to be "one of the best banks in the Deccan and has never given trouble." Yet the hydraulic gradient is only 2·8 to 1. A cross section of this dam is given in *Fig.* 2. An examination of the line of saturation shows at once the reason why this dam has stood so satisfactorily. It will be seen that half-way down the back slope there is over 30′ of dry moorum above the line of saturation. It is evident that this will be more than ample to check any tendency to slip on the part of the selected hearting. The line of saturation starting from the water level dips rapidly down through the inside moorum slope, till it reaches the clay hearting, when it flattens to about 1 in 5, but directly it gets through the hearting, it dips suddenly down at an angle of about 45° to within 10′ of the original ground line, and then runs out at about 1 in 6 to the outer toe of the dam. Compare this with *Fig.* 3 in which the line of saturation in the Matoba dams, a typical all-clay bank, is given. Instead of 30′ of dry moorum, there are 10′ of clay only to prevent slipping. Yet the hydraulic gradient of this dam is flatter than in the case of the Mukti tank. *Fig.* 4 shows the line of saturation of the Parsul dam, No. 10 in above table. This has been a very successful dam holding up 53′ of water with a hydraulic gradient of only 3 to 1. In this case very complete drainage is afforded by the heavy dry stone foundation under the outer toe, thus securing 24′ of dry material to prevent the hearting slipping. Thus instead of a 4 to 1 hydraulic gradient being necessary to secure safety, it is seen that the two most successful works investigated in Bombay have gradients of only 3 to 1 and 2·8 to 1, and that the safety of an earthen dam depends, not so much on the actual slope of the hydraulic gradient, as on the depth of dry material which can be secured in the back slope of the dam above the line of saturation.

The principles on which an earthen dam should be designed are then as follows :—

1. The inner slope should be such that there will be no danger of slipping when it is saturated.

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2. The earth between the inner slope and the hearting should be preferably of porous material, so as to admit water freely to the clay hearting and keep the latter wet, and thus reduce the tendency of the hearting to become dry and cracking.
3. In the centre of the dam should be a clay or puddle hearting of sufficient thickness to render the work more or less watertight.
4. As this clay hearting will never be quite watertight, it is necessary to drain the back of the hearting as thoroughly as possible, and to support it with a heavy backing.
5. This backing must be sufficiently massive to prevent all danger of slips.
6. The change in the nature of the various kinds of material used must not be too sudden, as this might tend to cause cracks under variation of temperature and moisture. Thus the clayey hearting should gradually change to porous backing—gravel should not butt straight up against clay.

The recent orders of the Government of India with regard to earth dams are to assume the line of saturation at 1 in 4, and to provide at least 8′ of dry earth over this. This will nearly always ensure a safe section whatever material the bank may be made of, but, as shown above, it is possible to obtain a much steeper line of saturation than 1 in 4 with perfect safety. It is impossible to give a type suitable for every case, but, judging from the results obtained in Bombay, the section given in *Fig.* 5 would appear to be perfectly safe for heads of water up to 50′ and very economical, and it will be seen that the section in *Fig.* 5 satisfies the above-mentioned six principles. *But suitable materials must be available for construction.* The most porous material in the dam should be a layer immediately behind the hearting, so as to take the line of saturation down to ground level as quickly as possible. Behind this layer any kind of non-slipping material may be used. Probably gravel, or some heavy material, is best. A dry stone toe is a great advantage in securing thorough and effective drainage and in preventing slips. But, as has been pointed out by Mr. Hill, there is danger of such stone toes becoming filled with wet earth forced into them by the pressure of the superincumbent bank. This can be prevented by arranging a layer of fine ballast between the earth and the stone toe.

In *Fig.* 5 the hydraulic gradient works out at 1 in 3·4. The line of saturation has been drawn in in a similar manner to that actually observed in the case of the Mukti tank (see *Fig.* 2), and there is no

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doubt that the actual line of saturation will approximate to this, *provided that suitable porous material is used* in the dam between the hearting and backing. There is a maximum depth of 28′ dry earth, and a minimum of 10′ over this line of saturation.

For heads of water of more than 50′, it would be desirable to flatten out the lower part of the back slope so as to secure 15′ to 20′ of dry earth or gravel as a minimum over the line of saturation.

In the case of porous non-slipping material not being available for the backing, the hydraulic gradient must be made flatter. For anything except a very clayey backing the Government of India rule of 8′ of dry earth over a 4 to 1 gradient should be perfectly safe, but for a pure clay dam even this might slip, and a flatter gradient have to be adopted.

As an example of a high earth dam, a cross section of proposed Tendula dam is given in *Fig.* 6. The maximum height is 109′, and 24′ of loose sand have to be removed from the bed of the river which is to be dammed. A quantity of loose stone will be available and this will be utilized to provide heavy stone toes. For a dam of this magnitude, the Government of India have assumed a line of saturation at 1 in 4, and a minimum of 10′ dry earth over it, with the extra precaution of the stone toe. The inner slope will be $2\frac{1}{4}$ to 1 only, but it will be heavily pitched with 12″ and 18″ stones, and it is not considered that there will be any risk of a slip. The construction of this work is just beginning.

It is interesting to note that in the typical high earthen dam as constructed in Europe, the line of saturation assumed at 1 in 4 passes well within the outer slope, in fact is more or less parallel to it. Thus see *Fig.* 1 in which the line of saturation has been drawn. Thus the result of Mr. Hill's observations is to prove the correctness of the principles on which European engineers have been designing earth dams, though these principles were not worked out by them on any experimental data, but were merely arrived at by empirical rules based on long practical experience.

II.—Design of the Waste Weir.

In every reservoir scheme, whether for waterworks, for irrigation, or for any other purpose, the provision of a waste weir to discharge safely surplus water is a prime necessity. A failure of the waste weir, or an inadequate discharging capacity, means a failure of the whole work, the loss of enormous sums of money and possibly of human life, to say nothing of the extreme inconvenience that is caused by a stoppage of the usual water supply. In temperate climates where the rainfall is moderate, and where accurate statistics are available for a long series of years, the design of the waste weir presents but

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little difficulty, and empirical rules based on past experience will usually give satisfactory dimensions. Such rules will be found in the standard books on waterworks engineering, where it is generally stated that it is advisable to limit the depth of flood water flowing over the crest of the weir to 2′ or 3′, and to allow a length of so many feet of weir per acre of catchment area. As full information can be obtained from these books, it is not proposed to further examine such cases here, but a little consideration of any particular case will show that the matter must be much more thoroughly gone into when the reservoir is to be built in a country subject to tropical rainfall, which may come in sudden bursts of 4″ per hour or even more, giving rise to sudden floods of very high intensity.

It is evident that the discharging power of the waste weir must depend upon the maximum flood which is likely to come into the reservoir, but it is a great mistake to make it equal to the estimated maximum flood discharge, though this has often been done, and large sums of money squandered in providing excessively long weirs. In the first place a lake or reservoir, formed by damming a river, acts as a regulator, and will have the effect of converting a short flood of high intensity into a prolonged flood of lower intensity. Thus take the case of the Lake of Lucerne. This is fed by a number of mountain streams while it is drained by the river Reuss, which flows out of the lake at the Lucerne end. During heavy rains, the hill torrents come down in floods of great intensity, but owing to the large area of the lake, its level is only raised a few inches, and the discharge of the Reuss only slightly increased. But on the other hand this increased discharge of the Reuss continues for many days after the hill torrents have resumed their normal dimensions. Exactly the same thing occurs in the case of an artificial reservoir, and the larger the water-spread area of the reservoir, the less will be the ratio of the maximum discharge over the waste weir to the maximum flood inflow. In fact in order to arrive at a reliable waste weir formula, it is necessary to take into account :—

(i.). The maximum flood discharge expected to flow into the reservoir.

(ii.). The length of time during which such a flood may be expected to persist.

(iii.). The water-spread area of the reservoir when full.

The maximum flood influx can be estimated by a consideration of the catchment area and rainfall records, by methods fully described in the textbooks, or, what is much more satisfactory, by looking up the gauge records of the river it is proposed to dam, where such records are available for a sufficiently long period. The length of

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time during which the maximum flood may be expected to persist must be arrived at by consulting the rainfall records and by general knowledge of the district concerned. When these figures have been fixed, the following formula can be applied :—

$$B=\frac{Ti}{2hA},\quad l=\frac{ni}{ch^{\frac{3}{2}}}.$$

When i=maximum estimated flood influx into the reservoir in cubic feet per second.

T=time in seconds during which such a flood may be expected to persist.

h=rise in the water level of the reservoir due to the flood i persisting for time T, or what is the same thing, the maximum depth of water which it is intended to allow to flow over the waste weir, or the difference between full supply and high flood level.

A=the area of the water spread of the reservoir in square feet, when the water level is midway between full supply and high flood level.

l=length of weir required in feet.

c=coefficient depending on the form of the weir. The value of c can be obtained from any textbook on hydraulics. For a sharp-crested weir with a free overfall $c=3{\cdot}25$.

B and n are quantities connected by a somewhat complex relation. Having found B, from the first equation, the corresponding value of n is obtained from the table below for calculating l by the second equation $l=\frac{ni}{ch^{\frac{3}{2}}}$. The proof of these formulæ is rather long, but it is given in the appendix.

As an example of the use of these formulæ, which were worked out by the writer in 1906 and are now used for calculating the lengths of all waste weirs for storage works in the Central Provinces, the maximum flood influx i, is calculated by Dicken's formula $i=cM^{\frac{3}{4}}$, where c is a coefficient, taken as 1,400 for Central Provinces, and M is the catchment area in square miles. It is assumed that this maximum flood will only persist for three hours. But it is also usual to calculate the weir for a prolonged flood of less intensity, viz. :—a flood due to a steady run off of $\frac{1}{2}$" depth of water per hour from the whole catchment area persisting for 24 hours. These are of course high figures, which would only apply to countries subject to tropical rainfall. But as regards the Central Provinces the results have been very satisfactory. To take a concrete instance, the calculations for the waste weir for the Bardih reservoir may be quoted. The data are :—

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TABLE.—Values of B and n.

For Flood Storage Formula.

B.	n.	Difference for ·001.	B.	n.	Difference for ·001.	B.	n.	Difference for ·001.
·50	·0	—	·80	·728	1·1	1·10	·908	·3
·51	·049	4·9	·81	·738	1·0	1·11	·911	·3
·52	·095	4·6	·82	·748	1·0	1·12	·914	·3
·53	·138	4·3	·83	·757	·9	1·13	·917	·3
·54	·178	4·0	·84	·766	·9	1·14	·920	·3
·55	·216	3·8	·85	·775	·9	1·15	·923	·3
·56	·252	3·6	·86	·783	·8	1·16	·925	·2
·57	·286	3·4	·87	·791	·8	1·17	·928	·3
·58	·318	3·2	·88	·799	·8	1·18	·930	·2
·59	·348	3·0	·89	·806	·7	1·19	·932	·2
·60	·377	2·9	·90	·813	·7	1·20	·934	·2
·61	·404	2·7	·91	·820	·7	1·21	·936	·2
·62	·429	2·5	·92	·826	·6	1·22	·938	·2
·63	·454	2·5	·93	·833	·7	1·23	·940	·2
·64	·477	2·3	·94	·839	·6	1·24	·942	·2
·65	·499	2·2	·95	·844	·5	1·25	·944	·2
·66	·520	2·1	·96	·850	·6	1·26	·946	·2
·67	·540	2·0	·97	·855	·5	1·27	·948	·2
·68	·559	1·9	·98	·860	·5	1·28	·950	·2
·69	·577	1·8	·99	·865	·5	1·29	·952	·2
·70	·594	1·7	1·00	·870	·5	1·30	·954	·2
·71	·610	1·6	1·01	·875	·5	1·35	·960	
·72	·626	1·6	1·02	·879	·4	1·40	·965	
·73	·641	1·5	1·03	·883	·4	1·45	·970	
·74	·655	1·4	1·04	·887	·4	1·50	·974	
·75	·669	1·4	1·05	·891	·4	1·55	·978	
·76	·682	1·3	1·06	·894	·3	1·60	·981	
·77	·694	1·2	1·07	·898	·4	1·80	·990	
·78	·706	1·2	1·08	·901	·3	Infinite	1·000	
·79	·717	1·1	1·09	·905	·4	—	—	

Full supply level 103
High flood level ... ... 106 } $h=3$

Area of water spread at mean of these levels, or at 104·5, 38,400,000 square feet.

Catchment area M = 8 square miles.

Then $i=1{,}400$, $M^{\frac{3}{4}}=6{,}664$ cubic feet per second, so that

$$B=\frac{Ti}{2hA}=\frac{3\times 60\times 60\times 6664}{2\times 3\times 38{,}400{,}000}=\cdot 312.$$

Turning to the Table, it is seen that if B is less than ·5, n is zero or negative. This shows that theoretically no weir at all is required,

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or, in other words that a flood of 6,664 cubic feet per second persisting for three hours would not fill up the reservoir to 106 level, even if no weir at all were provided.

Now consider a prolonged flood caused by $\frac{1}{2}''$ run off per hour persisting for 24 hours. The intensity of this flood will be in cubic feet per second

$$\frac{\frac{1}{24} \times 5280 \times 5280 \times 8}{60 \times 60} = 2582.$$

Calculating B again, we get

$$B = \frac{Ti}{2hA} = \frac{24 \times 60 \times 60 \times 2582}{2 \times 3 \times 38,400,000} = \cdot 968.$$

Turning to the Table the corresponding value of n is found to be ·854, so that

$$l = \frac{ni}{ch^{\frac{3}{2}}} = \frac{\cdot 854 \times 2582}{3 \cdot 25 \times 3^{\frac{3}{2}}} = 130 \cdot 6'.$$

A weir of this length will be more than sufficient to dispose of the maximum flood of 6,664 cubic feet per second for three hours. If, as has so often been done, the weir had been calculated of sufficient length to dispose of 6,664 cubic feet per second for an indefinite time, we should have

$$L = \frac{i}{ch^{\frac{3}{2}}} = \frac{6664}{3 \cdot 25 \times 3^{\frac{3}{2}}} = 394',$$

which is more than three times the length actually required. Waste weirs are often very expensive to construct, and this example shows clearly what an excessive length with consequent waste of money may be given by the old method of calculation.

It will be noticed that if L denote the length of weir of actual discharging power equal to i, the estimated intensity of the maximum flood likely to flow into the reservoir, then nL will represent the length of weir actually required, or, what comes to the same thing, it will only be necessary to design the weir to discharge ni cubic feet per second instead of i cubic feet per second. Thus, if the weir is a drowned weir or if there is a velocity of approach or other complications, the appropriate formula may be used, and the length of the particular kind of weir required will be calculated by that formula taking the maximum discharge over the weir as ni cubic feet per second.

It will be found in practice that, except for small catchment areas, or in cases where the water-spread area of the tank is comparatively small, the prolonged flood requires a longer weir than the maximum 3-hour spate. It is therefore best to calculate the weir first for the 24 hours' flood, and then check for the 3-hour flood. In using these formulæ, the difficulty is to fix the values of T and i. But if T be taken as 24 hours, then i, in the absence of more reliable local information, may be calculated from the equation

$$i = 37 m p \mathrm{M}^{\frac{5}{8}}.$$

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Where m is the maximum rainfall in inches recorded during *two* consecutive days in the neighbourhood of the proposed work

p is the estimated percentage of run-off.
M is the catchment area in square miles.

In this formula p may be taken as $\frac{3}{5}$ for an ordinary catchment with moderate slopes and a certain amount of vegetation. It may be as high as 80 to 95 per cent. in the case of bare rocky catchments with steep slopes, and in sandy catchments it may be below 50 per cent. But as we are considering maximum rainfall, the percentage of run-off will be high—much higher than the average annual run-off—and not so variable for different kinds of catchments.

This formula for i has not yet been tried in practical work, but it gives results consistent with current practice in India, America and England, so that it will probably be useful as a guide in calculating a weir in a country where there is but little previous experience to go upon. Adopting this value of i, the length of weir can be calculated by the above formulæ, taking T as 86,400″, and the length of weir should then be again calculated for the maximum probable 3-hour flood (taking T as 10,800″) and the greater of the two lengths adopted.

In this manner the length of the weir crest may be determined, but the safe discharge of the surplus water down the tail channel into a natural water course often presents a problem of some difficulty. By the construction of the reservoir, the level of the water is raised several feet above its old level in the river, and it is generally necessary to safely lead the surplus back to its old level. This involves a drop of several feet, and, unless the surplus water can be discharged over a rock bar, it is necessary to construct masonry works or falls at convenient points in the tail channel, and to limit the velocity between these falls to about 6′ per second, which is the most that unprotected earthwork can stand. The position and detailed designs of these falls will vary with each particular case, and it is impossible to consider the matter exhaustively here. Generally speaking, however, the most economical arrangement is to make the fall at the weir crest as low as possible and then rapidly contract the channel below the weir, and consequently increase the depth of the water. This will considerably reduce the cost of the second fall. Thus to take the case of the Bardih reservoir alluded to above. At high flood we should have 3′ of water running over the crest of the weir in a stream 130·6′ wide. Suppose we have to drop the water 20′ so as to deliver into a natural water course that no rock bar is available to discharge over, and that having regard to the nature of the soil it is not desirable to increase the velocity in the tail channel beyond 6′ per second. The maximum discharge to be dealt with is ni or $\cdot 854 \times 2582 = 2205$ cubic feet per second. At 6′ per second a waterway of $\frac{2205}{6} = 367$ square feet is required, so that if the depth of water be increased from 3′ to 6′, it will be possible to contract the

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tail channel from 130·6′ to $\frac{391}{6}$ or 61′. It is nearly always cheaper to make a channel 61′ wide and 6′ deep than a channel 130·6′ wide and 3′ deep. Also by running 6′ deep it will be found that the length of any falls which may be required will be considerably less than 61′, and a very large saving in masonry will be effected. The bed slope of the tail channel must of course be calculated by the usual formulæ so as to give a velocity not exceeding 6′ per second, and the dimensions of the falls must be calculated by the usual text-book formulæ for discharges over weirs, etc.

III.—Miscellaneous.

1. *Core and Face Walls.*—The general principles governing the design and construction of puddle cores are fully described in the textbooks, and a discussion of the method of substituting a selected earth hearting has been given above. But in many cases masonry core walls or face walls have been very successfully used. On the whole it would seem that a carefully constructed masonry wall is about as efficient as a puddle core as regards percolation, whereas in a hot dry climate it is safer and more permanent. It is, however, usually more costly. Masonry core walls have been largely employed in Rajputana, where the earth is generally sandy and good clay difficult to obtain. These masonry cores are placed in the centre of the dam, and carried down as far below ground level as may be considered necessary to secure watertight foundations. Being supported by earth on each side, they can be made quite thin. Thus for a wall 50′ high, a base thickness of about 4′ would be sufficient, and this might diminish by offsets to 2′ at the top. The same care should be taken in building these walls, as in the case of a masonry dam, to secure every joint being thoroughly and completely filled with mortar. The faces of the wall should be left as rough as possible and selected earth rammed tight against each face.

Face walls with an earth backing make very neat dams, but are rather costly. In such cases the section of the face walls must be worked out as a retaining wall to hold up the earth backing when the reservoir is empty. Many of the larger native dams in Rajputana have been built on this system.

2. *Watertightness of Reservoir.*—It is only possible to be quite certain that a proposed reservoir will be watertight, if a thorough geological examination of the basin is made and the existence of an impermeable stratum underlying the whole basin proved, and the foundations of the dam carried down well into this stratum. These conditions are usually obtained in the case of the more important European reservoirs, but are by no means always necessary to render a work a success. Large tracts of country frequently possess a more or less clayey subsoil. Dams constructed in such tracts with quite shallow foundations will frequently prove nearly watertight, or quite sufficiently so for all practical purposes. In the Central Provinces,

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for instance, the puddle trench at any point is usually taken down to a depth of about half the height of the water which will eventually stand over that point when the reservoir is full. This procedure has given very satisfactory results. In more porous strata, however, the matter is more difficult to decide. Colonel S. L. Jacob, C.I.E., who has constructed about 150 earth dams in the very varying soils of Rajputana, states that, in the absence of geological assurance as to the existence of an impermeable stratum underlying the whole basin, it is impossible to make quite sure of any proposed reservoir being watertight, and that the risk of failure to hold water satisfactorily appears to be greater in hilly tracts than in the plains. In the hills there is often less soil, and fissured rock may be nearer the surface than in the plains. But, provided there is a good depth of soil which is not of an obviously porous nature, it is generally possible to construct a satisfactory reservoir in flat or gently undulating country without any very serious risk of undue leakage. On the other hand, in the neighbourhood of hills, even very deep core walls will sometimes be nearly useless. At the back of the Alwar city in Rajputana is an old native dam constructed of earth with a thick masonry face wall, but the reservoir has never held water satisfactorily. The reservoir frequently fills, but after a week the water is all absorbed, and the reservoir becomes quite empty. The site of the dam is in a gorge between two hills, and the subsoil in the gorge consists of boulders and clay. A trial pit was sunk just in front of the face wall to explore the foundation of the latter, and it was eventually discovered that the face wall was founded quite 70′ below the surface of the ground in the same boulders and clay. One would naturally have thought that 70′ of boulders and clay compacted by several feet of water standing over it for prolonged periods would eventually become watertight. Yet, as mentioned above, this tank failed to hold water even for a week.

3. *Sand Dams.*—Colonel S. L. Jacob has constructed two very remarkable sand dams in the Jaipur State of Rajputana. One of these is described in Colonel Scott-Moncrieff's *Water Supply of Barracks and Cantonments*, p. 77, but encouraged by the success of this work, Colonel Jacob built a far more ambitious dam on the same principle at Ramgarh, some 25 miles from Jaipur. The site is peculiar. The *nala* which is dammed flows through a narrow gorge with steep rock sides, and the place appears to be an ideal one for a masonry dam. Examination showed, however, that there would be great difficulty with the foundations, as the bed of the river was composed of loose sand to a great depth. About a quarter of a mile above the gorge the river flows past a sand hill, and Colonel Jacob conceived the bold idea of constructing a sand dam on sand foundations at this point. The work has proved most successful, and has been built for only about half of what the masonry dam in the gorge would have cost. The dam is constructed of pure sand resting on

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sand. So loose is the sand that it has been found necessary to cover the whole of the back slope with stone pitching to prevent its being blown away by the hot weather winds. The dam is 80′ high and the greatest depth of water impounded up to date is 56′. There is a core wall of rammed "dhaminy" earth, that is sand mixed with clay or earth, carried up to the high-water line. This core is 8′ thick at the top and 22′ thick at the bottom. The inner slope of the dam is 4 to 1 and the outer slope 2 to 1. The hydraulic gradient at high-water level is about 1 in 5·5, but had the dam been turned round the other way, and the 4 to 1 slope placed downstream, the hydraulic gradient would be reduced to 1 in 9·5. There is of course a certain amount of leakage, but this is not a source of danger, as by an inverted filter bed arrangement at the outer toe all the leakage water comes through perfectly clear, and is unable to carry away in suspension particles of sand from the dam. All over the outer toe, and for some 10′ above it, is laid a layer of fine ballast, then another layer of coarser ballast, and finally a thick layer of stone pitching. This arrangement is quite effective. Two miles lower down a low stone weir has been built across the river, and this catches all the leakage, and diverts it down the canal which takes off just above the weir. This dam is probably quite unique. It has been in existence now for nine years, and has shown no sign of weakness.

There is a good deal to be said in favour of sand as a material for dams in cases where a certain amount of leakage is not of much consequence. Sand is easily consolidated so that no interstices are left, and, if an animal burrows a hole in the bank, this hole soon fills up again by loose sand falling in. Again sand is extremely cheap to dig and handle, and provided precautions are taken to prevent its being washed out at the outer toe by leakage, and the slopes are protected against scour and wind, the Jaipur experience shows that quite large dams can be successfully built of this material. One other precaution is necessary, and that is to introduce frequent creep walls at the junction of the sand with any masonry work. Water has a very pronounced tendency to flow along such junctions, and it appears almost as if the masonry had the effect of concentrating the flow in some way. The masonry must be thoroughly tied to the sand by frequent projections and offsets, so that the course of any water creeping along the face of the masonry may be as tortuous as possible. Similarly in the case of core or face walls in sandy soil, it is necessary to be very careful to project the ends well into the banks on either side. Many bunds have failed in Rajputana by percolation round the ends of the core walls. Of course no one would think of building a dam entirely of sand when suitable clay or earth is available. But there are many sites where little except sand can be obtained, and it is worth remembering that even with this apparently unfavourable material, successful reservoirs may be constructed.

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APPENDIX.

PROOF OF FLOOD STORAGE FORMULÆ.

It is assumed that the reservoir is just full of water up to the crest of the weir when the maximum flood of i cubic feet per second begins to pour into the reservoir, and it is required to find what time must elapse before the water level will rise h feet up to high flood level.

Let y be the height in feet of the water surface above the crest of the weir at t seconds after the commencement of the flood.

A_y be the area of the surface of the water when the water level is y feet above the weir crest.

C_y be the quantity of water in cubic feet in the reservoir above the level of the weir crest, when the water level is y.

l = length of weir in feet.

Δ = discharge over the weir in cubic feet per second.

Then by the usual formulæ for weir discharges

$$\Delta = lcy^{\frac{3}{2}}$$

where c is a coefficient depending on the form of weir.

For a sharp-crested weir with a free overfall $c = 3{\cdot}25$ approximately. Hence we have the flood i pouring into the reservoir and an outflow over the weir of $lcy^{\frac{3}{2}}$. Hence the nett increase in the quantity of water in the reservoir is $i - lcy^{\frac{3}{2}}$ and evidently

$$\frac{dC_y}{dt} = i - lcy^{\frac{3}{2}}$$

But

$$\frac{dC_y}{dy} = A_y,$$

so that

$$\frac{dt}{dy} = \frac{A_y}{i - lcy^{\frac{3}{2}}}$$

and

$$t = \int \frac{A_y\, dy}{i - lcy^{\frac{3}{2}}}.$$

Now this integral will have to be taken between the limits $y = 0$ and $y = h$, where h is the maximum depth of water to be allowed on the weir crest. But h will be small compared with the the total depth of water in the reservoir, and hence without sensible error, we may replace A_y by its mean value A, A being taken as the mean of the areas of the surface of the water at full supply and high flood level respectively.

We then get

$$t = \int_0^h \frac{A\, dy}{i - lcy^{\frac{3}{2}}}$$

where A is constant.

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The integration is rather troublesome, but may be performed by putting $\sqrt{y} = x$, $i/cl = a^3$, $x/a = z$, when it reduces to

$$t = \frac{2A}{acl}\int \frac{z\,dz}{1 - z^3}$$

$$= \frac{2A}{acl}\left\{ \tfrac{1}{6} \log \frac{1 + z + z^2}{(1 - z)^2} - \frac{1}{\sqrt{3}} \tan^{-1} \frac{2z + 1}{\sqrt{3}} \right\} + \text{constant.}$$

To find the constant, we have $t = 0$, when $y = 0$, $x = 0$ and $z = 0$, so that

$$\text{constant} = \frac{1}{\sqrt{3}} \tan^{-1} \frac{2z + 1}{\sqrt{3}} = \frac{\pi}{6\sqrt{3}} = \cdot 3023.$$

The integral has to be taken between the limits $y = h$ and $y = 0$. When $y = h$, we have $z = x/a = \sqrt{h}/a$, so that $a = \sqrt{h}/z$, and $cl = i/a^3 = iz^3/h^{\frac{3}{2}}$.

Therefore $$\frac{2A}{acl} = \frac{2Ah}{iz^2}.$$

Hence between the limits h and 0,

$$T = \frac{2Ah}{iz^2}\left\{ \tfrac{1}{6} \log \frac{1 + z + z^2}{(1 - z)^2} - \frac{1}{\sqrt{3}} \tan^{-1} \frac{2z + 1}{\sqrt{3}} + \cdot 3023 \right\}.$$

For $$\frac{1}{z^2}\left\{ \tfrac{1}{6} \log \frac{1 + z + z^2}{(1 - z)^2} - \frac{1}{\sqrt{3}} \tan^{-1} \frac{2z + 1}{\sqrt{3}} + \cdot 3023 \right\}$$

write B.

Then $$T = \frac{2ABh}{i}, \text{ and } B = \frac{Ti}{2Ah}.$$

Writing n for z^3, we have also

$$cl = ni/h^{\frac{3}{2}}, \text{ or } l = ni/h^{\frac{3}{2}}.$$

Hence we have the formulæ

$$B = \frac{Ti}{2Ah} \text{ and } l = \frac{ni}{Ch^{\frac{3}{2}}}$$

where B and n are connected by the relation indicated above. It will be seen that B is entirely a function of z, and therefore of n, so that it has been possible to construct a table giving the values of n for any value of B, and thus make these formulæ, though depending on a troublesome integration, extremely simple to use practically.

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NOTES ON SKI.

By Capt. A. D. St. G. Bremner, R.E.

As there are probably many who have never tasted of the joys of ski-ing, the following notes by one who has served his apprenticeship in Switzerland during the past three years, may perhaps serve as an introduction to one of the finest sports in the world, and one which at the same time also has its military uses.

Historical.

The earliest mention of ski-ing of which we have at present any record occurs in Procopius (526—559 A.D.), who mentions a race of Skridfinnar, *i.e.*, gliding Finns.

The word ski however has nothing to do with "gliding" or "sliding," but belongs to a group of words, Gothic-Skaidan, German-Scheiden, Latin-Scindere (Scidi), Greek Οχυζειν which imply "splitting," and refers to the original method of making the ski. It is properly pronounced "she," but in Switzerland there is a tendency to pronounce it as "skee," as the former pronunciation has another meaning in the French language. Ski have been used in warfare from a very early date in Sweden. It is recorded that King Swerre, at the Battle of Oslo in 1206, sent out a captain and company of ski-runners to reconnoitre.

An interesting description of ski-ing is to be found in Sir Arthur De Capel Brooke's *A Winter in Lapland and Sweden*, 1827. The military use of ski is insisted upon and 50 miles is put down as a fair day's work for a Lapp.

In those early days the use of the ski was certainly utilitarian in the main, and ski were employed very generally all over Scandinavia for military purposes and for locomotion in winter. Old State papers have been discovered in Norway showing that competitions for soldiers were held as far back as 1767, but as a sport its history may be said to date from the introduction of peasants from Telemark (a province in Norway) to Christiania about 1870.

Before this time, however, it is interesting to note that ski appear to have been used in Great Britain, being used about the sixties in the last century by the Weardale miners in Cumberland to go to and from their work. In 1883 the Norwegian Ski Association was founded and held their first meeting on the Huseby Hill, but, as this hill faced south and was often in bad condition, the venue was changed to the world-famous Holmenkollen Hill in 1892.

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Ski-ing is now the national sport of Norway and has worked wonders in developing the physique and spirited self-reliance of the nation. The best Norwegian runners are at present unsurpassed.

In 1890 came Nansen's *First Crossing of Greenland*. This book, which contains a long and admirable account of the sport written in the language of an enthusiast, created a stir in mountaineering circles.

Mountaineering, originally introduced by our countrymen, had for some time been popular in Central Europe both amongst the Swiss, Germans and Austrians, but in winter the Alps were practically a sealed book; in the ski, however, climbers thought they had discovered something more serviceable, and experiment soon verified their expectations. Many Ski Clubs have since been formed all over the world, amongst them being the Ski Club of Great Britain founded in 1903 and the Scottish Ski Club in 1907. The former may be regarded as the M.C.C. of sport as far as Englishmen are concerned.

There now seems a likelihood that all the different associations of Europe will soon be united into one large body with one set of competition rules and regulations.

Uses of the Ski.

Civilian.—In the mountainous regions of temperate climates snow often makes communication from one valley to another difficult, if not impossible, unless the roads are kept open at great expense. Every house outside the villages is isolated, and much privation and suffering caused to those stricken with poverty or illness. Every village remains cut off from the rest of the world for weeks and months at a time owing to the deep snow covering the ground. Necessity has in some countries developed various patterns of snow shoes. These are unfortunately only of little help when the snow is soft and deep; their employment is laborious, especially on steep slopes. The ski, however, does not present the same inconvenience, consequently the rapidity with which it has been introduced into the mountains of Central Europe is not to be wondered at. The snow is now no longer an obstacle, nor are expeditions confined to the summer season.

Children go to school on ski in Switzerland and the skill they attain to is marvellous, while the mountain postmen are also provided with them and are becoming very expert.

Another application, entirely sporting, consists in being towed over the level by a horse, and is called skijoring, the skier holding the reins in one hand and the traces in the other, or the latter are fastened to his body—a more dangerous arrangement.

Military.—Most countries have adopted ski for troops stationed in

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the mountainous regions, especially the Alpine regiments of France and Italy, and the Swiss detachments on the St. Gothard. The Norwegians, Swedish, Russians, Germans and Austrians employ them for winter manœuvres, more especially for scouting. The only difficulty experienced is that of keeping the men together and under control, above all during the descents.

Owing to the initiative of the Swiss Officers' Society, courses of ski-ing were organised in 1904 for officers and N.C.O.'s of all arms in different parts of Switzerland, in particular at Zweisimmen, Gryon, St. Croix, Mont-Soleil, Simplon, Andermatt and St. Moritz. Since 1907 the Swiss Government has interested itself in these courses and have provided the necessary funds. The programme of these courses includes technical exercises, *i.e.*, in the use of ski and tactical exercises. These latter consist mainly of patrolling and scouting practices.

There is no finer exercise than ski-ing to develop the muscles or presence of mind. It is wonderfully bracing when combined with the glorious sunshine and clear fresh air of the mountains. Compared to skating, the apprenticeship served is shorter; while the skater is often confined to the same surface, sometimes very restricted, the skier has for his ground the plains, forests, hills, mountains and valleys, in fact almost any surface with snow.

Some Ski-ing Countries.

British Isles.—The opportunities for ski-ing in this country are far more frequent than most people imagine. The Welsh and Scottish mountains are often covered with snow for many weeks and even months at a time, and of lower lying ground, the Peak District in Derbyshire and the country around Sedbergh in Yorkshire may be mentioned. The Highlands of Scotland are very suitable for ski-ing and no one could desire a better country than that near towns like Kingussie, Newtonmore or Dalwhinnie, which are within a comfortable night's journey of London. The best month is probably February. Gamekeepers, shepherds, postmen, doctors, etc., who have to make journeys across the hills in all sorts of weather, are now beginning to appreciate and use ski on the Grampians also, and doubtless the custom will soon spread to other parts of the country.

The Ski Club of Great Britain, and the Scottish Ski Club, have admirable arrangements whereby members are supplied with information by telegram concerning the snow in almost any part of the country, and their year books contain very useful information about ski-ing at home. The address of the former club is 1, Great George Street, Westminster.

Norway.—The sport centres in the country round about Christiania, which is within a short two days' journey of England. The district

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is covered with pine forests and is undulating rather than mountainous in character. The big jumping competition takes place at Holmenkollen which is a hill within half-an-hour's journey of Christiania. The date fixed is usually the end of February or the beginning of March.

Christiania however suffers sometimes from a deficiency of snow, and even after a snowfall the snow is very soon beaten down by the large number of ski-runners crossing it. A visit up country to such places as Telemarken, Gudbrandsdalen and Oesterdalen should therefore be made. There are also vast plateaux lying above the tree level from which spring the higher mountains. All this upper ground is called fjaeld and should not be omitted. Fefer is a comfortable little place, and at Norsaater, near Lillehammer, and Mysusaeter, near Otta, rougher but cosy quarters are obtainable. Other places are the Hardanger Vidden and Bessheim in the Jotunheim Mountains. The best time of the year to go to the fjaelds is about the middle of March, as the days are then longer and good ski-ing is often to be had, close to the big glaciers, even in June!

Maps may be obtained at Christiania, but they are not very good; a compass is also essential.

The cost of living is small, running about 5s. 6d. to 8s. 6d. per day.

Sweden.—The country round Stockholm is, in general, too flat and not very suitable. There are, however, two admirable jumping hills. Skijoring is a favourite pastime with the Swedes, and other sports abound—such as skating, ice-sailing, etc.

The province of Jemtland, easily reached by train, is perhaps the best ski-ing resort in the country, and a good centre is Are on the line between Stockholm and Trondhjem. Storlien, further up the line, is also good, and expeditions may be made across the frontier into Norway and also to the Syl Mountains. The general character of the country is like the Norwegian fjaelds and the same remarks apply.

Germany.—The Feldberg, in the Black Forest, is perhaps the nearest certain ski-ing ground within easy reach of London. The ground is admirable, being mostly undulating, as in Norway, with plenty of long open hills and plenty of wood. There is a first-class jumping hill near the hotel. February is usually the best month.

The only drawback to the district is the fogs to which it is somewhat liable. The ordinary outfit, not forgetting maps and a good compass, is all that is necessary.

Switzerland.—The chief centres are Adelboden (4,450′) Chateau-d'Oex (3,500′), Arosa (4,720′), Davos (3,115′), Engelberg (3,355′), Grindelwald (3,500′), Wengen (4,200′), Montana (5,000′), St. Moritz (6,090′) and Villars (4,250′), to give an adequate description of which would fill a large volume. Prices run from about 10 francs a day

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upwards. The Swiss ground is in general steeper than that previously mentioned, and ordinary tours take the form of climbing some mountain or pass and running back to the hotel. January is the best month.

The Austrian Tyrol.—The general character of the ground is not quite so steep as Switzerland, but steeper than Norway or the Black Forest. St. Anton, St. Christoph, Innsbruck, Kitzbühel and Zell-am-See are perhaps the best-known places, and all contain jumping hills. A large number of well-found inns and club-huts are scattered about all over the country at heights of 7,000 or 8,000′ above sea level; using these as centres, an endless series of tours can be undertaken until about the middle of March, often considerably later.

The above by no means exhausts the places where good ski-ing may be had. The French and Italian Alps and the Vosges, for instance, are delightful, as also are the Erzebirge, Riesengebirge and Bohmerwald Mountains. Even Australia is not without its ski-runner.

The Ski.

This is of course the most important part of one's outfit. The wood from which ski are made should be cheap, hard, springy, tough, and light. It should also be of an even consistency throughout, *i.e.*, without soft layers. Hickory would be perfect if it were cheaper, less heavy and tougher. Ash, too, would be perfect if it were less expensive and heavy, and if it did not contain soft layers. Birch is light, but apt to be brittle. Pine, though serviceable, is soft and also brittle.

Ash and hickory are the most widely used, especially the former, but all ash is not equally good. Genuine Norwegian ash is excellent, but it is getting scarce. Danish ash and the best German and Swiss ashes are good. The weight of an ash ski is a very good guide to the merit of the wood, as good ash is heavy.

Another test is the "grain." The less grain there is about an ash ski the better, as the grain portion is softer, more porous and brittle than the remainder. It soon wears away into grooves which tend to clog and slow the running. The best wood for making ski is that which is cut from the outside of the lower part of the trunk. It is preferable that the grain and good wood should be in horizontal rather than vertical layers. Such layers should, in any case, "run out" as little as possible, and that little should not be at the bend or under the foot, and should be in a direction running from toe to heel and not *vice versâ*.

The Telemark type of ski is recommended for all-round service and is made in different sizes. The ordinary rule is that the ski, when stood vertically against the body, should reach to the middle of the fingers with the hand held above the head.

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A ski has two bends in it, one running throughout its entire length and forming a gentle arch so that when unweighted the ends alone stand on the ground, and the other the upward turn in front called the bend. The total height of the arch should not exceed three-quarters of an inch, but too little is better than too much. The section is either rectangular or rounded on the upper surface, and most patterns have a groove, generally semicircular, about one-twelfth of an inch deep on the lower or running surface to facilitate straight running. The ski is parallel in plan, except at the bend where it is rather wider and then runs off to a point, and at the rear end which is also a little broader than the centre portion. It is most important that a ski should be absolutely true, otherwise it will not run straight.

A skilfully fashioned bend is the hall-mark of a first-class ski. It should begin very gently and subtly and should on no account be abrupt and exaggerated. A total rise of 5″ or 6″ is amply sufficient.

The thickness of wood at the bend is also important; it should be comparatively thin to make it as springy as possible, since the bend is the place where the ski will most likely break.

The upper surface and sides are best varnished, though some are painted; the lower surface should be coated with linseed oil mingled with a little paraffin. A sling for carrying a ski is required when rocks have to be climbed; it is not necessary for ordinary tours.

Binding.—A really good binding should be (1) strong, (2) light, (3) compact, (4) easily repaired, (5) easily put on and taken off, (6) cheap, (7) comfortable, (8) such that the foot is secured so that under *all ordinary strains* it is rigid as regards lateral movement. The heel of the foot should be *partially* free to move up and down vertically. This vertical movement should be such that the heel can easily rise for 3″ or so from the ski, after which the heel should be checked mechanically by the binding, so that it rises with increasing difficulty till the runner can just kneel comfortably on the ski. Care should be taken that the toe strap never reaches further down the foot than the joint where the big toe joins the foot. No existing binding fulfils all the above conditions, but the Huitfeldt pattern, combined with Ellefsen's Clamp for the heel strap, is one to be recommended. It consists of an iron leather-covered side plate, passing through a slot in the ski to which the toe strap is fastened. A strap is carried from the iron plate round the heel of the boot. The Ellefsen binding is also good, but the writer does not recommend the use of other types.

It is usual to have some sort of footplate and perhaps the simplest as well as the most durable is a very thin piece of metal, such as brass or zinc, secured at the corners by small screws and elsewhere by a few plain nails.

Sticks.—Use double bamboo or hazel sticks reaching to the shoulders, and provided with biggish wicker rings suitably fixed. The

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lower ends of the sticks are generally iron pointed. Their uses would take too long to describe here, but the beginner had better at first leave them behind until a certain proficiency has been attained.

Sealskin.—There are numberless dodges to prevent ski slipping back when climbing, such as sealskin (fixed or detachable), wedges, etc. Perhaps the simplest and cheapest is a kind of net made of rope, which is slipped over the front half of the ski and made fast to the boot.

On the other hand, in warm weather snow is apt to stick to the ski. The cure for this is wax, rubbed on while hot to the running surface. There are several kinds of wax on the market made up in various degrees of solidity. It is best to dry the ski before applying any of these preparations.

Repairing Outfit.—It is well to be provided with such as the following:—(1) A "tin toe," sold in all the shops; (2) a strong gimlet; (3) a handy tool comprising, a hammer, a small axe, a pair of pliers and a screw-driver all in one; (4) some small pieces of sheet brass with holes round the edges; (5) some small screws and other nails; (6) a long leather thong, spare straps and string.

The Rucksack.—Should be capacious but made of light material. Leather is too heavy. A couple of outside pockets are a great convenience for articles which are constantly in use. The shoulder straps should be broad.

Boots and Socks.—The ski runner cannot be too particular about his boots. They should be strong, waterproof, pliable and large enough to contain the foot covered by an ordinary pair of thick socks, as well as a special pair of ski socks made of goats' hair. The Lotus ski-boot (English made, costing 35s.) is excellent and superior to those made on the Continent. With a cork sole, two pairs of Army socks, a pair of long woollen stockings and putties outside all, it is possible to keep the feet absolutely dry and warm. It is important too that the fit round the instep and ankle should be quite perfect or sore heels may result.

A few small nails in the soles and heels are an advantage for crossing ice when carrying ski. Dubbin should be used sparingly to keep the leather soft and pliable.

Gloves.—The inner covering should be woollen without separate divisions for the fingers and reach a little above the wrists. The outer covering may well be made on the same plan out of the rubbered canvas sold for patching motor tyres, and should reach well above the end of the coat sleeve with some sort of tightening arrangement to prevent the entrance of snow.

Headgear.—A light cap with a flap round the edge, which may be drawn down over the tops of the ears, is useful, but by far the best thing is the ordinary woollen Balaclava cap, generally worn folded up.

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Other Clothing.—The underclothing should be of wool or flannel, and the coat and knickerbockers of some closely woven material to prevent wind penetrating, but it must be smooth stuff. Pockets should be capacious and have flaps which can be buttoned down. Some of them may with advantage be lined with waterproof. A light warm sweater is also serviceable.

Goggles are often worn, especially in Norway and Sweden, as a protection against snow-blindness.

As regards the actual practice of ski-running, it is impossible to go into the subject here. It is best to study some good book before commencing practical instruction, and the following are recommended :—

Ski-ing for Beginners and Mountaineers, by W. R. Richmers.

How to Ski, by V. Caulfield.

The Ski-Runner, by E. C. Richardson, to which I am largely indebted for the above notes.

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THE SPACING OF STIRRUPS IN REINFORCED CONCRETE BEAMS.

By Capt. T. E. Kelsall, R.E.

When designing reinforced concrete beams, it is generally necessary to introduce stirrups or other means of providing against failure by horizontal shear. In the case of uniformly loaded beams the shear is a maximum at the ends, diminishing to zero at the centre, the shear stress diagram for each half of the beam being a triangle. Consequently if equally spaced stirrups are used their sectional area has to be varied to correspond with the varying stresses.

An alternative method, which has practical advantages, is to assume a distance from the end of the beam for the first stirrup, the sectional area of which can then be calculated, and to make all the others of the same dimensions, their spacing being increased towards the centre of the beam. Some simple means of ascertaining this spacing is therefore necessary.

Vertical stirrups, so spaced that perpendiculars through them cut off equal areas of the shear stress diagram, would appear to be correctly spaced. This is presumably true also of diagonal stirrups, if the perpendiculars are drawn from similar points in all of them.

Knowing the length of the beam and the distance of the first stirrup from the end, the distances of the others can be calculated.

The following two sets of general expressions give the distance in feet of the various stirrups from the end of a beam whose length is L feet, when the first stirrup is 6″ and 1′ respectively from the end of the beam :—

Distance in feet of stirrups from end of beam.

		1st stirrup $\frac{1}{2}'$	1′
2nd	,,	$\frac{1}{2}(L-\sqrt{L^2-4L+2})$	$\frac{1}{2}(L-\sqrt{L^2-8L+8})$
3rd	,,	$\frac{1}{2}(L-\sqrt{L^2-6L+3})$	$\frac{1}{2}(L-\sqrt{L^2-12L+12})$
4th	,,	$\frac{1}{2}(L-\sqrt{L^2-8L+4})$	$\frac{1}{2}(L-\sqrt{L^2-16L+16})$
5th	,,	$\frac{1}{2}(L-\sqrt{L^2-10L+5})$	$\frac{1}{2}(L-\sqrt{L^2-20L+20})$
6th	,,	$\frac{1}{2}(L-\sqrt{L^2-12L+6})$	$\frac{1}{2}(L-\sqrt{L^2-24L+24})$
7th	,,	$\frac{1}{2}(L-\sqrt{L^2-14L+7})$	$\frac{1}{2}(L-\sqrt{L^2-28L+28})$
8th	,,	$\frac{1}{2}(L-\sqrt{L^2-16L+8})$	$\frac{1}{2}(L-\sqrt{L^2-32L+32})$
9th	,,	$\frac{1}{2}(L-\sqrt{L^2-18L+9})$	$\frac{1}{2}(L-\sqrt{L^2-36L+36})$
10th	,,	$\frac{1}{2}(L-\sqrt{L^2-20L+10})$	$\frac{1}{2}(L-\sqrt{L^2-40L+40})$

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Working out these expressions for various values of L, we get the following tabular statements :—

Length of Beam in Feet ...		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Number of stirrups in each half length of beam.		3	3	4	4	5	5	6	6	7	7	8	8	9	9	10
		′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
Approximate distance from end of beam of each stirrup in feet and inches.	1st	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6
	2nd	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
	3rd	2.2	1.11	1.10	1.9	1.9	1.9	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7
	4th			3.0	2.8	2.7	2.6	2.5	2.4	2.4	2.4	2.3	2.3	2.2	2.2	2.2
	5th					3.11	3.6	3.4	3.2	3.1	3.1	3.0	2.11	2.11	2.10	2.10
	6th							4.10	4.4	4.1	4.0	3.10	3.9	3.8	3.7	3.7
	7th									5.8	5.2	4.11	4.8	4.7	4.5	4.5
	8th											6.7	6.0	5.8	5.5	5.4
	9th													7.6	6.10	6.6
	10th															8.5

Length of beam in feet.		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Number of stirrups in each half length of beam.		1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6
		′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
Approximate distance from end of beam of each stirrup in feet and inches	1st	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2nd		3.0	2.7	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.1	2.1	2.1	2.1	2.1
	3rd						5.0	4.3	4.0	3.10	3.9	3.8	3.7	3.7	3.6	3.5	3.5	3.5	3.4	3.4	3.4
	4th										7.0	6.0	5.8	5.5	5.3	5.1	5.0	4.11	4.10	4.10	4.9
	5th														9.0	7.9	7.4	7.0	6.10	6.7	6.6
	6th																		11 0	9.7	9.0

For intermediate lengths of beams the spacing can be obtained with sufficient accuracy by interpolation. For longer beams the spacing can be worked out from the general expressions. The general expressions for the 11th and subsequent stirrups will be evident from an inspection of those given above for the first 10.

The general expressions and tables are only given for two alternative distances of the first stirrup from the end of the beam, as this will usually give sufficient latitude in designing.

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General Sir James Frankfort Manners Browne, K.C.B.,
Colonel Commandant, Royal Engineers.

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MEMOIR.

GENERAL SIR JAMES FRANKFORT MANNERS BROWNE, K.C.B., COLONEL COMMANDANT, ROYAL ENGINEERS.

By Col. R. H. Vetch, c.b., late R.E.

Sir James F. M. Browne was born in Dublin on the 24th April, 1823. He was the only son of the Very Rev., the Hon. Henry Montague Browne (1799—1884), Dean of Lismore, who was the 2nd son of James Caulfeild Browne, 2nd Lord Kilmaine. His mother was the Hon. Catherine Penelope, daughter of Lodge Evans Morres, 1st Viscount Frankfort de Montmorency She died in 1858.

Educated at Epsom and at Mr. Miller's at Woolwich he entered the Royal Military Academy in May, 1838, and received his first commission in the Royal Engineers on 1st January, 1842. From the R.E. Establishment at Chatham, of which Colonel (afterwards General Sir) C. Pasley was at that time Director, he went to Woolwich, and thence to Ireland. In March, 1845, his turn for foreign service came round and he was sent to Halifax, Nova Scotia. In April he was promoted 1st lieutenant and in November, 1846, he was moved to Quebec.

In June, 1847, Lieut. Browne was sent on special service to Fort Garry in the Red River Settlement, Hudson's Bay Territory (now Manitoba). A detachment of Royal Artillery and another of Royal Sappers and Miners with three companies of the 6th Foot had been quartered at Fort Garry since the summer of 1846. They were sent there on account of a good deal of restlessness and some ill-feeling along the line of frontier between Canada and the United States of America, in connection with the demarcation of the boundary between the two countries. The officers of Royal Engineers and the Sappers and Miners were employed in surveying, improving the portages, and other engineering work, and in superintending the clearance of forest in the neighbourhood by the troops and other pioneering work, as well as strengthening the defences of the Upper and Lower Forts Garry. So difficult and arduous was the journey that it took two months for Lieut. Browne in the height of summer to reach what was then a rather inaccessible spot, and is now the

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prosperous city of Winnipeg. A diary of his journey to Fort Garry, written at the time, has been found among the General's papers. The route taken, the primitive conditions of the country, and the mode of travel into the western regions was so different at that time when the west was indeed the "wild west," and the sport he met with on the way was so interesting that I have appended to this memoir a *résumé* of the journal kept by Lieut. Browne.

In August of the following year the troops were withdrawn from Fort Garry and Lieut. Browne returned to Quebec, but whether he went back by the same route there is nothing to show. The time occupied in the return journey was only half that taken to reach Fort Garry a year before, and it must be assumed that knowing the ropes there were fewer delays and stoppages.

In the autumn of 1851 Lieut. Browne returned home and was sent to do duty in Ireland for the next two years, first at Clonmel and then at Kilkenny. He was promoted to be 2nd captain on the 7th February, 1854, and in the following July was sent to Chatham to command the 1st Company of Royal Sappers and Miners. He put it through a course of fieldwork instruction and on the 5th January, 1855, embarked with it for the Crimea.

On reaching Balaklava on the 5th February the company was at first employed for a short time in putting up hutting for the troops and for stores, but Engineers were too much wanted at the front for this employment to continue and Capt. Browne and his Company were soon moved to the trenches of the British right attack on Sebastopol. Here Capt. Browne began that arduous and prolonged duty in the trenches which lasted until near the end of August.

On the 22nd March, 1855, and again on the 5th April, Capt. Browne took part in the repulse of sorties made in force by the Russians. He was promoted to be 1st captain on the 1st June, 1855, and was the Senior Executive Officer of Engineers on the 7th June, when he rendered conspicuous service in the successful attack on the Quarry outworks covering the Redan. The execution of the arrangements as well as the general superintendence of the work was in his hands. Capt. (now Field Marshal Viscount) Wolseley of the 90th Foot was his assistant engineer, and Capt. Browne reported in high terms of his conduct on this occasion. Capt. Browne was mentioned in the despatches both of Sir Harry Jones (8th June), and of Lord Raglan (9th June), for his gallantry and zeal. On the 17th July a brevet majority was conferred upon him for his services.

When Lieut.-Colonel Richard Tylden, R.E., director of the right attack, was fatally wounded in the unsuccessful attempt to assault the Redan on the 18th June, 1855, his duties devolved on Major Browne who, for rather more than two months, carried on the work of this responsible position. On the 24th August Major Browne was severely wounded by a rifle bullet, which broke his left arm, passed

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through the shoulder, and injured his jaw. He was in hospital until the 18th November when he was invalided home. He was mentioned in Sir Harry Jones's despatch of 9th September, 1855. For his services in the Crimea he was created a Companion of the Order of the Bath, Military Division, and a Knight of the Legion of Honour, he received the war medal with clasp for Sebastopol, the Sardinian and Turkish medals, the Order of the Medjidie (5th class) and a second brevet, that of lieutenant-colonel, was gazetted on the 26th December, 1856. A pension of £200 a year was awarded him for his wounds for three years, but this was afterwards made permanent.

Recovering from his wounds at the end of 1856 Colonel Browne was quartered in Dublin until July, 1859, when he went out to India to command the Engineers in the Bombay Presidency with headquarters at Poona; in March, 1860, he went on to Mauritius as Commanding Royal Engineer and in August, 1861, he returned home to take up the appointment of Superintendent of Military Discipline (now called Assistant Commandant) at Chatham, where he was second in command, and had special charge of the drill and training of the battalions of Royal Engineers quartered there. He was promoted to be brevet colonel on the 26th December, 1864, and regimental lieutenant-colonel on the 2nd May, 1865.

On the 1st January, 1866, Colonel Browne was moved from Chatham to headquarters at the War Office, as Assistant Adjutant-General for Royal Engineers, and five years later, he succeeded Colonel the Hon. H. F. Keane as Deputy Adjutant-General. In July, 1870, he was a member of the committee on the pay of officers of Royal Artillery and Royal Engineers and in January, 1873, on the admission of gentlemen educated at the universities to the scientific corps. He was selected for a distinguished Service pension in October, 1871.

On the 1st January, 1876, Colonel Browne was appointed Colonel on the Staff and Commanding Royal Engineer of the South Eastern District with his headquarters at Dover, but his promotion to be major-general on the 2nd October, 1877, (afterwards antedated to 22nd February, 1870) placed him on the half-pay list. On the 2nd June, 1880, he was appointed Governor of the Royal Military Academy at Woolwich. He remained in this post for 7 years, was promoted to be lieutenant-general on the 13th August, 1881, was placed on the unemployed list in 1887, and was promoted to be general on the 12th February, 1888. General Browne retired on a pension on the 5th May, 1888. On the 6th April, 1890, he was made a Colonel Commandant of Royal Engineers, and on the 26th May, 1894, he was created a Knight Commander of the Order of the Bath.

He died at his residence, 19, Roland Gardens, London, on the 6th December, 1910. His remains were buried in Brompton Cemetery, after a funeral service at St Peter's, Cranley Gardens, on 10th

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December. The King was represented at the funeral service and at the grave by Colonel R. C. H. Buckland, R.E., Aide-de-Camp to His Majesty.

On his twenty-seventh birthday, April 24th, 1850, Sir James Browne was married at Quebec, Canada, by the Lord Bishop of the diocese to Mary, daughter of James Hunt, of Quebec. She died at 19, Roland Gardens, London, on the 30th May, 1888, and was buried at Brompton Cemetery on 2nd June. By her he left two unmarried daughters; Annie Kathleen de Montmorency, born in Dublin 1858, and Agnes Montague, born in London in 1867.

A portrait in oils of the general painted by Mr. Charles Lutyens, is in possession of his daughters.

His sword hangs with those of other Governors of the Royal Military Academy in the dining hall of the cadets and his daughters are making an altar frontal for the Chapel in memory of him.

A "RÉSUMÉ" OF A JOURNAL OF TRAVEL FROM QUEBEC TO FORT GARRY, RED RIVER SETTLEMENT, HUDSON'S BAY TERRITORY, MADE BY LIEUT. J. F. M. BROWNE, R.E., BETWEEN 28TH JUNE AND 26TH AUGUST, 1847.

Leaving Quebec on the 28th June, 1847, with instructions to proceed immediately to the Red River Lieut. Browne and an officer of the Commissariat named Darling made their way by a succession of steamers up the St. Lawrence and through Lake Ontario, calling at Montreal, La Chine, Kingston, and Toronto to Queenstown where they arrived on the evening of the 3rd July and went by a horse tram to Niagara putting up at the Clifton House. On the 4th they remained all day at the Falls and visited the battlefields of Queenstown heights, Lundy Lane. On the 5th they left the Falls for Chippewa by wagon and there embarked in a steamer for Buffalo. They left Buffalo in the evening in the "Niagara" steamer for Chicago, a voyage of 1,080 miles, through Lakes Erie, Huron and Michigan. They stopped on the way at Cleveland, Detroit, Mackinaw Straits and Manitou Islands, arriving at Chicago on the evening of the 9th July, not bad going for the distance.

At Chicago they arranged for the conveyance of their baggage by wagon to Galina and, to allow time for it to get there before they did, remained at the Lake Hotel at Chicago until the 14th. The weather being oppressively hot the stage by which they travelled left at 2 o'clock in the morning, and driving through prairie land all night and the following day, they covered 180 miles, reached Galina at 7 p.m. on the 15th, and put up at the American hotel. Galina, known for its lead mines, Browne describes as the hottest and most uncomfortable place he was ever in; it was built on the banks of a muddy river called Fever River, 6 miles from the Mississippi. Here they waited for a steamer from St. Louis to take them to St. Peters in Iowa Territory. They met two men at the hotel who belonged to the Red River and were waiting

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for the same steamer as themselves; they agreed to join company as these men undertook to convey their baggage across the plains from St. Peters to the Red River Settlement. They brought horses, harness, a wagon, etc., and provisions (consisting principally of ham and biscuits) for crossing the plains.

The "Cara" steamer arrived in the evening of the 17th and they were glad to embark all their baggage and horses and to get away from Galina. For the next four days they steamed up the Mississippi, passing on the third day the lodges of Winnipeg and Sieux Indians. In the evening of the 21st July they reached the village, of St. Pauls, in Wisconsin territory, where they disembarked and had all their baggage put in a store. They put up at the house of a Mr. Jackson, but apparently there was not room for both of them to sleep there, because Browne says "Darling slept inside and I slept in the store." St. Pauls was 8 miles below St. Peters and was the village where most of the Red River traders kept their carts, horses, etc.; situated on the east bank of the Mississippi it was more convenient for them than St. Peters. "It is," says Browne, "a wretched place and the inhabitants about the greatest known blackguards. There were a good many Sieux Indians about, generally drunk." The next day Browne and Darling rode over to St. Peters to see Capt. Eastman, the officer commanding the American garrison at Fort Snelling. They crossed the Mississippi in a flat-bottomed barge, the fort being on the west bank, near where the St. Peter's River runs with the Mississippi. The captain gave them letters for the Red River garrison. They then visited the American Fur Company Establishment, leaving their horses at the fort and crossing the St. Peter's River. Mr. Libley who was in charge was very civil and gave them a good dinner which was most acceptable as there was nothing but salt pork to be got at St. Pauls. After posting letters at the fort, where the post office was kept, they returned to St. Pauls, and Browne pitched his tent at the back of the houses to avoid mosquitoes and vermin.

On the 23rd July about 1 p.m. they started on their march for Fort Garry, a party of 11 men and a boy, including themselves, 15 carts drawn by horses and oxen and Browne's wagon. They camped at the Falls of St. Anthony on the Mississippi, about 9 miles from St. Pauls and the same distance from St. Peters. Here Browne was able to shoot some prairie fowl for supper. They had to remain at the falls until the 27th July as some of their men expected freight to come by the next steamer for conveyance to Red River. The steamer arrived on the evening of the 26th, but not the expected freight; so, on the morning of the 27th, they began to travel up the east bank of the Mississippi, Browne and Darling riding. They did about 14 or 15 miles a day the carts being heavily laden and the oxen slow. On the 27th they breakfasted at Drunken River and camped at Corn River; on the 28th the places named are Rum River and Elk River. On the 29th they camped at Bear Island in the Mississippi, where it was very pretty and Browne shot duck. On the 30th they breakfasted at Chain of Lakes and camped at the Sac Rapids on the Mississippi. Next day they forded the river without accident, about 50 miles above St. Peters.

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The Mississippi at that place was about ¼ mile wide and at that time about 3′ 6″ deep and very rapid, with a rough, strong bottom. There was an island in the middle which made the crossing easier. Five or 6 miles after crossing the river they met a large party of half-breeds belonging to St. Pauls who had been buffalo hunting near Lac Travers. They had killed a good many and their carts were loaded with dried meat. The half-breeds told Browne's party that they would fall in with buffalo and elk and that a large party of traders from St. Pauls for Red River were three days ahead, also that two parties one of 180 and the other of 72 of Sieux Indians had crossed the track going eastwards on the warpath against the Chippeways. Browne scoured the country vainly in search of game. Their horses were much annoyed by a horsefly called "Bulldog" which bit severely.

On the 1st August they were compelled to halt all day to repair the carts which had suffered from the bad tracks. Darling was greatly alarmed by rattlesnakes and the horses could not feed on account of the "Bulldogs." On the 2nd August they reached the Sac River. The next day was very wet and as Darling was unwell they remained in camp. On the 4th they moved across the Sac River, and Browne saw a wolf, but the beast got into cover before he could get a shot in. He also saw deer for the first time, and had a long chase after a fine buck, but the buck got into a swamp and crossed the river. Darling was too ill to ride and travelled on a cart. At night he was delirious. They got to the edge of the great prairies on this day. Next morning Darling was better and Browne took the seat off his wagon, on which they made a bed for him, which he used for the rest of the journey. They were now in the Sieux country and established a watch at night for the first time, and pushed on by day as fast as possible.

On the 7th August they reached a part of the country called the "Height of Land," because it was the highest country between Red River and St. Peters. They saw swans, pelicans, geese, and ducks on some small lakes they passed. They crossed the trail of a party of about 25 Sieux going westward, evidently part of the war party of 72 that they had heard of and were glad that the Indians had not crossed behind them as they might have followed to steal some of their horses. Water and wood were scarce. They camped at a small lake where Browne managed to shoot a few ducks. On the 8th Darling was very ill with fever and ague. They saw the tracks of three small parties of Sieux going westward who had crossed about two days before. On the 9th they camped by a very pretty lake, where there were swans and pelicans and a great number of ducks. There was an Indian encampment which had been left about a week before, supposed to belong to Chippeways on a warpath against the Sieux. At sundown there was a terrific thunderstorm and the rain lasted till daylight. As Browne had given up pitching his tent and generally lay under a cart he had a bad time of it.

10th and 11th August. Getting off at 6 a.m. they halted for breakfast at 11 a.m. on the Mimence prairie, where they dried their blankets, etc., and got away again in the afternoon; two of their men went on ahead towards the Otter-Tail Lake River to look for buffalo, but were

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unsuccessful. An object was seen ½ mile away on the right which, at first, they took to be Indians and Browne with a man who could talk Sieux language rode towards it. It turned out to be three elks, or more properly Wapiti deer. Giving the man his shooting coat and nearly everything but his gun and ammunition Browne prepared for a chase. The deer allowed him to ride quietly up to within about 200 yards before they made off, with Browne after them. But he had not ridden more than ¼ mile when his horse got his forelegs into a narrow swamp sinking up to his chest and, throwing Browne over his head, fell on his side. They both scrambled out unhurt and Browne continued the chase until the deer crossed swamps where he was unable to follow. He was returning to the track of his party, when he met Darling's servant, Miller, riding his master's horse, and a few minutes later getting a view of the deer again gave chase and ran them for 5 or 6 miles, when the largest of them showed signs of being done up and running into a swamp with high grass threw himself down. Miller jumped off his horse and ran into the swamp with a large horse pistol, which missed fire but caused the deer to jump up and make off again. Browne followed him and shot him dead. He proved to be a very large specimen with fine horns. Browne sent Miller off to get a cart for the meat and was to wait by the deer until his return.

Near sundown Browne got uneasy and rode off to look for the track, which unfortunately for him had taken a long round to the left to avoid some lakes, of which he did not know. He hunted about for the track until quite dark; then he unsaddled and having tied his horse by a line round his own waist, he sat in his saddle being unable to sleep as he had only his shirt and trousers on and the mosquitoes were dreadful. Towards morning it became very cold and he was quite wet through from the heavy dew. When day broke he could not find his way back and wandered about the prairie in search of the track without success, there being a heavy mist which did not clear away until about 9 o'clock. After another hour he got very hungry. He felt totally lost and began to consider which was the most tender part of his horse in case of necessity. However, an hour later, Miller and two other men, who had been out looking for him since daylight, appeared. One of the men went back to the cart to tell Darling that his friend was found, while Browne and the other two men went in search of the deer. They found it and sent for a cart. By the time they overtook their party it was crossing the Otter-Tail Lake River, which is the head water of the Red River. Darling had been very anxious about Browne's absence, and some of the party, wishing to push on on account of the Indians about on the warpath, had objected to waiting to search for him. Browne always said that Darling by the firm stand he made, in spite of his own illness, had saved his life.

Starting early on the 12th August they had to travel till 2 p.m. before they could find water and then it was bad. Browne saw seven wolves run out of the swamp just as they came up to it, but his horse was too tired to hunt them. He also saw a herd of the small jumping deer which the half-breeds call antelopes, pretty animals a little smaller than the

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common American deer and much faster. A violent thunderstorm came on in the evening which wet them through and put out the fires so they had to go to sleep supperless.

Darling was so ill next morning that they remained in camp. One of the men fancied he saw buffalo and Browne and five of the men got their guns and rode off. When they got to the Red River, some 2 miles from the camp, they found instead of buffalo a party of traders under the command of Mr. Kitson of the American Fur Company, who had left St. Peters a few days before them, and taken a round to the west to trade with the Indians in the Sieux country. Browne and his men crossed the river and dined with the Kitson party and agreed to join parties for the rest of the journey, and, as Kitson's route was more westerly than their own, Browne hoped to get buffalo. When they returned to their own camp near evening, Darling was better and they brought up all their carts, etc., ready to cross the river in the morning. Then another party belonging to a man named Hayden, of Red River, appeared, and it was agreed that the three parties should travel together on the west bank of the Red River. It was an extraordinary circumstance three parties meeting on the prairie on the same day.

On the 14th August the whole cavalcade consisting of 25 men and 50 carts assembled on the west side of the Red River. Where Browne crossed at this time of the year the river was about 80 yards wide and 3½′ to 4′ deep. When the party halted in the evening at Rice River it was found that the bridge had been carried away. So they set to work to make a new one, by cutting down trees and throwing them lengthways into the river and laying willows across them. When it was completed next day the crossing was effected, but with some trouble. Browne and Kitson rode on ahead towards the Shyenne River and Kitson spied a buffalo bull. Riding on quietly they hoped to drive him towards their carts. They got within 150 yards of him before he saw them, and then started off. Browne rode alongside of him and fired, missing the first barrel, but hitting him in the shoulder with the second. He fell on his knees and nose, but got up again and went off very slowly. Browne reloaded and rode up in front of him, on which he faced Browne shaking his head and tail furiously but did not attempt to charge. At this time Browne was not more than 12 yards from the bull, but could not get his horse (who had never seen buffalo) to stand quiet. He fired again and hit the bull in the chest, but he walked off and not till another shot hit him between the shoulders did he fall dead. They skinned part of the beast and carried away some of the meat, which they found very tough, but better than the salt junk they had lived on so long. He was a very old bull, which accounted for his not running as well as they generally do. Cows run much faster and further than bulls. That night the party encamped on Shyenne River and had another thunderstorm.

On the 16th they camped on Maple River and next day crossing that river Browne and Kitson were ahead when they saw a buffalo bull and riding up to within 100 yards Browne fired from horseback and missed him. He went off and they followed. Browne got another shot which hit him behind and Kitson hit him in the back, then Browne stopped him

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with a hit in the shoulder and riding up close killed him. He was an old bull blind in one eye which may have accounted for their being able to get close before he started. That night they camped on the Rush River. On the 18th they saw no game and camped near a swamp with very bad water. Next day they hunted two bulls Browne killing one and Kitson the other. Halting at a swamp for dinner Browne managed to kill another bull. They came across the track of the Red River buffalo hunters and followed it till they reached a bend of the Goose River where they camped. Large herds of buffalo were in the hills all round them. They were all tired of bull meat and arranged to start early on the 20th to kill some cows.

Browne, Kitson, and some of the men after riding for some time discovered a herd which they had some difficulty in approaching on account of the number of bulls, who were very shy. At last by riding along the edge of a low lake they got a good start and Browne singled out a cow which he killed after a run of a couple of miles over a bad, hilly and stony country. The cow was not very fat but much better eating than bull meat. Kitson also killed a cow and having cut them both up they sent a cart for them. Towards evening Browne killed his sixth bull. There were plenty of calves which run even better than the cows. The whole country was covered with buffalo and Browne greatly regretted he hadn't two or three horses as he might have killed many more. "A wounded bull," he says, "will often charge if a man goes too close and his horse is not well trained, but the principal danger is from your horse putting his foot into a badger hole and falling."

On the 21st they camped on Turtle River near the place where Mr. Simpson, the Arctic voyager, was found shot. The next day the weather continuing very hot they camped on Salt River and Darling, being a little better and very anxious to get to the end of his journey, they determined to go ahead of the main party, hoping to reach the settlement in four days. On the 23rd Browne, Darling, his servant Miller, the Sieux interpreter Campbell, and two brothers named Spence pushed on ahead. They had two carts with them as light as possible. Darling's horse was in the wagon, while his servant drove their cart. They halted for dinner at Little Hillock Creek and went on again until evening, when they were obliged to stop on account of the loss of a linchpin of the wagon, and there was no water for the poor horses. Having repaired their wheels as well as they could their baggage carts being very old and shaky, they crossed the Tongue River on the 24th, watered their horses and just as they were close to Pembina River their cart broke down altogether. They were obliged to transfer their traps to Spence's cart and put in their horse as leader and so reached the river. On the 25th they reached the Grand Point on the Red River and pushing on got to Scratching River in the evening where they camped. As they were little more than 40 miles from the settlement Browne determined to push on by himself in the morning and try to reach Fort Garry early enough to send fresh horses for Darling next evening. Leaving at 5 a.m. on the 26th he rode as fast as

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he could and got to the fort by 11 a.m. Darling was got in the next day and the baggage four days after them.

Itinerary.

Quebec to Montreal	180	miles.
Montreal to Kingston	186	,,
Kingston to Toronto	188	,,
Toronto to Niagara	40	,,
Niagara to Buffalo	23	,,
Buffalo to Chicago	1,075	,,
Chicago to Galina	180	,,
Galina to St. Peters	328	,,
St. Peters to Red River Settlement	600	,,
Total	2,800	miles.

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TRANSCRIPT.

RAILWAY CONSTRUCTION IN THE FAR EAST.

From an article by V. Rikachev in the November, 1910, number of the *Injenerni Jurnal.*

THE condition of China at the close of the last century presented a pitiable spectacle of utter helplessness. Her government, after a historical life of 3,000 years, possessing an enormous territory and a population of over four hundred millions, with all the resources necessary for a flourishing commerce and trade, yet found itself obliged to submit with humiliation to the territorial and concessional requisitions of foreigners.

Her war with Japan in 1894–95 exposed her utter weakness without and within. The attempt at civil war in 1900 ended equally unsuccessfully. The loss of Formosa and the Pescador Islands, the declaration of independence in Korea and it passing under Japanese protection, the occupation by Europeans of Kwantung, Wei-hai-Wei and Kiau-chow, awoke China from her long sleep, and forced her to recognize that all fear of her elementary strength had irrevocably gone. To guard the integrity of her empire, not visionary powers, but actual armies and actual fleets were necessary wherewith to support her foreign policy, and she needed also considerable pecuniary resources.

As to these last, she took various measures for regulating and augmenting her supplies, and one of the most important of these measures was a plan of extensive railroad construction, calculated to cover the vast territory of the middle empire with a network of railways. This plan was calculated upon the enormous impulse which the new communications would give to the development of trade and industry, and to the transference of labour from the thickly populated to the almost unpopulated districts, and this impulse, it was hoped, would in time relieve the government from chronic poverty and onerous dependence on foreign governments.

Pekin and the Secondary Railway Centres.—In the scheme of development Pekin, as the centre of administration, acquires great importance as a railway centre. It is proposed that from here main lines shall run in four directions:—(1) South, to Hankau and Canton; (2) North, to Kalgan, Urga and Kiakhta; (3) East, to Tien-tsin, Shang-hai-kwan, Hsin-minting, Taonanfu, Tsitsikar and Aigun; and (4) West, to Tai-yuen, Langchau, Uruntsi and Kuldja. The scheme further proposes that Si-ngan, Hankau and Canton shall become secondary railway centres, and that from these cities lines shall run in all directions.

The Southern Main Line.—The main line from Pekin to Hankau was constructed in 1905 and has a total length of 748½ miles. Its extension to Canton is important in view of the proposal to extend the eastern main

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line to the Amur. By April, 1910, some 130 miles had been constructed northwards from Canton and work was also being commenced southwards from Hankau.

Two branch lines have already started from the southern main line :—(1) From Ching-ting station to Tai-yuen (capital of the Shansi province); and (2) from Kai-fong-foo to Honan, in the province of the same name. The first is 165 miles in length and the second 145 miles. The second of these branch lines follows the southern bank of the river Hwang-ho, and will be extended to Si-ngan, the capital of the Shensi province.

The Northern Main Line.—Of the northern main line, the portion Pekin to Kalgan (145 miles) had recently been finished. The line was made entirely by Chinese engineers and with Chinese materials, and its opening to traffic was an occasion of great rejoicing. A branch, 12 miles in length, from Pekin to Mantougou, in a colliery district, belongs to this system.

Kalgan is the trade centre of Mongolia and has a population of more than 100,000. Its trade with Southern China will be greatly benefited by the extension to Canton. The northern extension to Urga and Maimachen, called the Transmongolian railway, will encourage the trade and the settlement of Mongolia. At present in this direction there is only a *kutcha* road through the Gobi Steppe which shows great vitality, in spite of the difficulties of the way. The soil is rich and suitable for cattle rearing.

The Chinese Administration attaches great strategic and commercial value to this line, but at present the means for its construction are not forthcoming. Parallel to this the Russians have started a proposal to run a line from Missovaya to Kiakhta. The ruling considerations of this project are briefly these :—Now that the line has been opened to Kalgan, the extension of a Chinese railway into Mongolia and so on to the Russian frontier is only a matter of time. If the Russian branch line to Kiakhta is not then completed the strategic equilibrium will be upset unfavourably to Russia. If this branch were made, then the Russians could rely upon the argument of the 48 pairs of trains a day on the Siberian line, and upon the Irkutsk military district, to confine the Chinese to the peaceful development of their line for goods and passenger traffic.

It is estimated that with the double line of the Siberian railway, and with the proposed rate for expresses of 1,000 kilometres in 24 hours, the journey from Paris to Pekin, *viâ* Berlin, Petersburg, Perm, Omsk, Irkutsk and Kiakhta will take 9 days and 5 hours, from Moskow to Kiakhta 4 days, and to Pekin 5 days. In this case it is certain that all the European mails to China, and an enormous number of passengers will go by this route. As regards commerce exchange, the line will carry Hankau tea to Russia, and Siberian corn, timber, coal, etc., into China.

The Eastern Main Line.—The eastern main line, Pekin–Tientsin–Kinchow–Kou-pangtzu–Hsin-ming-ting–Mukden, with a branch Kou-pang-tzu–Ying-kou (Newchuang), is run entirely by Chinese, except that the chief agents are Englishmen. The portion Hsin-ming-ting–Mukden was made during the Russo-Japanese War by the Japanese, who used their own materials and labour, but it has since been handed over to the Chinese.

In this way the Chinese eastern main line is connected up with the

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Japanese Southern Manchurian system, and, through the latter, with the Russian East China railway. But the Chinese Road Administration, in order to be independent of foreign lines, has formed a project to carry forward their line from Hsin-ming-ting, through Fa-kuo-men and Tsitsikar to the Amur. As part of this project a line 20 miles in length has been opened from the Tsitsikar station on the East China railway to the town of the same name. The original project has since been modified, and the line, as at present projected, will run from Lanshanwan, through Kinchow and Taonanfu to Tsitsikar and Aigun.

The Japanese press considers that the project of constructing a line from Kinchow to Taonanfu has every prospect of realization. The line will pass through Chao-yang, on the river Taling-ho, and Fusin, and probably Chentsiatun. The length of this portion is estimated at 516 miles, and the extension to Tsitsikar would be 480 miles more. Undoubtedly, say the Japanese, the cost of such an undertaking would be beyond the powers of the Chinese, and the fact that they are considering it seriously points to a powerful backing of American capital.

The English papers announce that the line will run as follows:—

Kinchow—Shao-kulin	197 miles.
Shao-kulin—Chentsiatun	218 ,,
Chentsiatun—Taonanfu	148 ,,
Taonanfu—Tsitsikar	150 ,,
Tsitsikar—Aigun.....	250 ,,
Total	963 miles.

The author has checked these distances and makes the total 1,099 miles, and, including the extension to the sea at Lanshanwan, 1,119 miles. Serious difficulties will be met with in the mountainous country between Kinchow and Chentsiatun, and between Mergen and Aigun, where it will be necessary to tunnel the Khingan Mountains.

As regards fuel, this line will pass in the neighbourhood of four coalfields:—(1) Lian-shan, which is about 6 miles from Nan-yuan-chow, the third station to the west of Kinchow; (2) Lin-heisk, 11 miles to north-west of Kinchow; (3) about 46 miles to west of Taonanfu, in the spurs of the great Khingan, the Chinese report large seams of beautiful coal; and (4) Gan-heisk, 33 miles west of Mergen, on the right bank of the Gan-ho.

If the line Pekin-Kiakhta, in a strategic sense, threatens to cut off Transbaikal from Russia, the Kinchow-Aigun line is still more menacing, as it crosses the East China railway at Tsitsikar, and threatens the line of the Amur with an inroad at Blagovyeshchensk. To this must be added another menace, the request of the Japanese for rights to construct a line from Tieh-ling to Taonanfu. In fact if this project is completed before the completion of the Amur railway, the Russian position in the Far East might become very critical. Economically, the development of the Taonanfu district is very promising.

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To the eastern system there also belongs the line from Pekin to Tunchow (on the Pei-ho), 13 miles in length, which was made by the English in 1901 to connect the capital with the wharfs, and is very important.

The Line from Kwang-cheng to Kirin.—Another branch of the eastern main line is the line from Kwang-cheng to Kirin, which was to be begun in 1910. *Kwang-cheng* at the present time gains importance by being the borderland of Russian and Japanese influence in Manchuria. It is a centre from which a very large quantity of farm products is exported to Europe, China and Manchuria, supplying a large traffic on both the Russian East China and the Japanese Southern Manchurian lines. *Kirin* is of considerable strategic importance, and economically it will supply Southern Manchuria with timber and the products of the hills.

For the construction of this line an agreement was made between Japan and China, of which most of the advantages rest with the Japanese. By the agreement the two nations took equal shares, but the control will long remain with the Japanese, as to meet their share of the cost the Chinese were obliged to borrow from the S. Manchurian Railway Company on a 25-year agreement without the right of redemption of the loan before the end of that period. The line is 80 miles in length. and should be finished in the autumn of 1911.

Lines to the West.—Up to the present the only lines running westwards in China are the two branches already mentioned, to Tai-yuen and Ho-nan. The latter will eventually extend, beyond Si-ngan, to Lang-chow, the capital of Kansu province.

From Lang-chow at the present time a *kutcha* road runs to the frontier of the Russian Semiryetchensk province, and to Kashgar. There is another *kutcha* road running westwards from Kalgan, through Uliassutai and Kobdo, to the Tomsk frontier. Another important trade route runs south-west from Kalgan, along the Hwang-ho, and beyond, to Tibet.

Secondary Railway Centres.—Si-ngan.—Turning now to the schemes of development of the secondary railway centres, we will take first Si-ngan, the chief town of the Shensi province. From here it is intended that lines shall run in five directions:—To Tai-yuen, Lang-chow, Ching-tu (province Cze-chuen), Hankau (province Hu-peh), and Hai-fong-foo (province Honan).

Hankau.—From Hankau, already a very important trade centre, lines are to run:—Northwards to Pekin, north-westwards to Si-ngan, eastwards to Nanking and Ngan-king-foo, southwards to Nanchang and Canton and westwards to Ching-tu.

The Chinese government are fully alive to the strategic importance and the urgency of connecting Hankau and Ching-tu. By the latest accounts they had authorized the deputies of the Hupeh and Czechuen provinces to raise Chinese capital for the construction of this Hankau-Czechuen railway, hoping to be able to prevent foreign capitalists from intervening. But the agents of three foreign governments were trying to obtain influence in the line, the English, probably on account of Tibet, wanted the portion

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nearest to Ching-tu, the French wanted the same portion, while the American financiers had not quite decided upon what they wanted.

Canton.—The railway now under construction from Hankau to Canton passes through two large manufacturing towns Changsha and Heng-choo-foo, and will eventually be connected with the railway system designed for the province of Yunnan. Canton has at present no railway except that to Hong Kong, but it will in time, in addition to these northern and western connections, be linked up with Macao, Amoy and Fuchow, on the coast.

Chinese Turkestan, Tibet and Yunnan.—In the west and south of China the following lines are proposed:—In Chinese Turkestan a line from Lang-chau to Kuldja connecting the provinces Kansu and Sin-kiang; in Tibet a line from Ching-tu to Lhasa; in Yunnan there is already a line from Li-ngan to Laokai, on the Tonking frontier, connected through Hanoi and Namdinh with the coast, in the Gulf of Tonking. A concession has also been given to the French for the construction of the Yunnan-Annam railway, and the English are proposing a line from Yunnan to Burmah. Besides this the French have already completed a line from Chen-nankuan, on the Tonking frontier, to Lung-chau, in the province of Kwang-si, which the Chinese will extend to Nan-ning, and from there to Wuchau, on the West River.

Shanghai.—On the east coast, from Shanghai, there are two lines, one, completed, to Nanking, and the other, which is approaching completion, runs to Hang-chau, Ning-pu and Fenching on the borders of the Chekiang province. This last is, up to date, the biggest work of the Chinese engineers, and it is surprisingly good. The stations are built in handsome style in brick and stone, the bridges are of solid construction and the line is made double throughout. The rolling stock is American.

Nanking.—Nanking, the ornament and pride of the Yangtsi valley, whose silk industry was destroyed by the Tai-ping rebellion, is now reviving under the influence of its railway connection with Shanghai. Opposite to it, on the north bank of the river, is Pukou, the terminus of a line from Tientsin which is now under construction. This line will connect the east coast and northern railway systems. It should be completed early in 1912, and passes through a country rich in coal, hides and other products.

The line from Shanghai to Nanking is of English construction. Surveys have already been made for an extension to Wuhu, about 50 miles. In the course of 5 or 10 years there is little doubt that Nanking will be connected up with Hankau.

Shan-tung.—In the province of Shan-tung the Germans have made a line, 250 miles in length, from Kiau-chau to Tsinan, and a branch, 36 miles in length, to Bo-shang.

Such is the scheme of railway development which, when it is realized, will make China one of the richest countries in the world. That her warlike strength will also revive rapidly is very doubtful. Her conditions of government are difficult and complicated, and her present backwardness leaves her a great deal of leeway to make up.

Railways in Korea.—Seoul-Wiju Main Line.—The railway centre in Korea is the capital Seoul. The main lines run to Fusan and Wiju, with branches

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completed to Chemulpo, Chenampo and Masanpo, and under construction to Kunsan. The extension to Antung and Mukden is being reconstructed to broad gauge. Lines are also projected from Seoul to Gensan, from Ping-yang to Gensan and from Song-chin, through Horiong, to Kirin.

Needless to say Korea owes its network of railways to the enterprise of the Japanese. Their method of construction is so interesting that it deserves to be explained in full detail.

At the time of its construction the Fusan-Seoul main line had extreme importance, for in it the Japanese saw the key to the economic and political occupation of the country. The extension to the Yalu is completed with the exception of a few of the stations.

The line, along its whole length, is broad gauge (5′), well made and fully suited to the heaviest traffic. The bridges and tunnels however are designed for a single line, and complicate the question of the proposed duplication of the line.

During the construction, the Japanese paid chief attention to the line and the rolling stock. They have large Pullman cars for passengers of all three classes, wagons of dimensions and carrying power approximately double those of the Russians, and engines suited to these conditions. The stations were at first temporary, rough, structures, and are being gradually remodelled in keeping with the prosperity of the line. In this way Japan carries forward, in an economical manner, her strategic policy, pushing forward her lines, and afterwards, as they begin to pay, equipping them for commercial requirements.

The line from Fusan to Seoul is 274 miles in length, from Seoul to Wiju 312 miles, and from Wiju to Mukden 190 miles.

At the time of writing, when the reconstruction of the Antung-Mukden line had actually commenced and materials were collected for building a bridge over the Yalu, the strategic importance of the Korean main line was greatly increasing.

It will be possible for the Japanese troop trains to make the uninterrupted journey from Fusan to Mukden in two days, and taking into consideration the size of their wagons it can be seen at once not only how quickly Japanese troops can appear at Mukden, but also how quickly they can concentrate there.

Regarding the proposed lines, that from Gensan to Ping-yang will connect up the eastern and southern coasts of the peninsula and two existing fortresses. The line Songchin-Horiong-Kirin will approach the flank of Vladivostock and might serve as a base for cutting it off from Russia.

Fusan.—The Japanese are making great efforts towards developing the town and port of Fusan, they are constructing a large mole in the harbour, building a wharf and extending warehouses.

Even in its existing state the accommodation allows of six ships being unloaded, simultaneously, directly into railway trucks. When the new work is finished this will be considerably increased.

In connection with the details already given of the lines to Mukden it may be added that the passages from Nagasaki, Sasebo, Moji and Simonoseki to Fusan are each about 12 to 14 hours. The most careful

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arrangements are made towards facilitating and hastening the transference of troops from the islands to the mainland. In case of war, no time will be wasted in mobilization, but the men will be sent on board unequipped, without transport, provisions, etc., and will find everything necessary for them already in Korea, where equipment, weapons, provisions, stores, etc., are collected in arsenals and stores, distributed all over the country in accordance with the war scheme and the points selected for disembarkation.

Wiju.—The new town of Wiju, which forms the northern terminus of the Korean main line, still presents the unfinished, temporary, appearance which it owes to its hasty construction during the war, with enormous godowns, constructed of various materials, and large levelled spaces. But it has a great future, and is already beginning to show the effects due to the development of the Antung-Mukden railway.

Antung-Mukden Railway.—The Antung-Mukden railway was hastily built by the Japanese during the war, and afterwards secured to them by treaty with China. It is of narrow, 30″, gauge, and looks like a toy railway, with toy trains, no separate classes and no attempt at comfort. None the less the line works, and, at small cost, it was of enormous use to the Japanese during the war. Each truck will carry more than 2 tons of goods, and the small Baldwyn engines will drag as many as 12 trucks on level ground. The line was begun in the summer of 1904, and by October it was completed as far as Finhuangchen; three months later trains were running to Lanshanguan, and went far towards making possible the defeat of the Russians at Mukden.

The country is mountainous and the line has very steep gradients and very sharp curves. The bridges, 20 in number, are made of wood. In certain sections, at the stations Man-tsia-pu, Hziao-gou, Tsiunu-chuan and Tsi-guan-shan, the trains are divided and run in halves. At some of the sharper curves there have been many accidents, and in consequence of the danger, trains are only run by day, and the journey from Antung to Mukden at present takes two days, Tsao-ho-kow station being the halfway house.

In its present state the line is a brilliant example of military engineering but has little commercial value, but in their treaty with the Chinese, the Japanese secured the right of not only keeping up the line in its original state but of adapting it to commercial uses, in other words of reconstructing it into a wide gauge railway of permanent type.

In the reconstruction it has been decided to follow the original direction. The work consists in constructing bridges, excavating tunnels, reducing gradients and widening the track. The length of the reconstructed line will be 170 miles. By the latest information the work was being pressed forward rapidly, 60,000 Chinese coolies being employed, and it was hoped that the sections Mukden–Pensiu and Antung–Kikwanshan would be opened to traffic in the autumn of 1910. The present year should see the whole line completed and also the bridge over the Yalu, and then the journey from Mukden to Wiju could be accomplished in eight to nine hours, and Fusan would be connected with Europe by an uninterrupted line of rail.

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In this way Japan, having annexed Korea, will, in the very near future, be able to concentrate her troops at Mukden by means of the two lines from Fusan and Port Arthur. In other words she now stands face to face with Russia, while, as opposed to China, she has already cut her way into the very heart of Manchuria.

Sakhalin.—It remains to say a few words about Sakhalin. The Japanese while colonizing the coasts of their part of the island, have decided to make four railway lines, starting from the old Korsakovsk post, where their civil and military administrations of the island are concentrated. These lines are (1) from Ostamar (Korsakovsk) to Sakaiham; about 24 miles of this line are already completed, and the whole line, about 70 miles, will probably be open in 1913, (2) a line along the west coast covered from the side of the United States of America and (3 and 4) two lines on the east coast covered from the Russians.

As elsewhere, the character of the work shows moderate cost, and no undue haste to obtain luxuries. Compared with Japanese methods, the Americans build rapidly and expensively, the Russians, in the opinion of the author, build still more expensively and astonishingly slowly.

F. E. G. SKEY.

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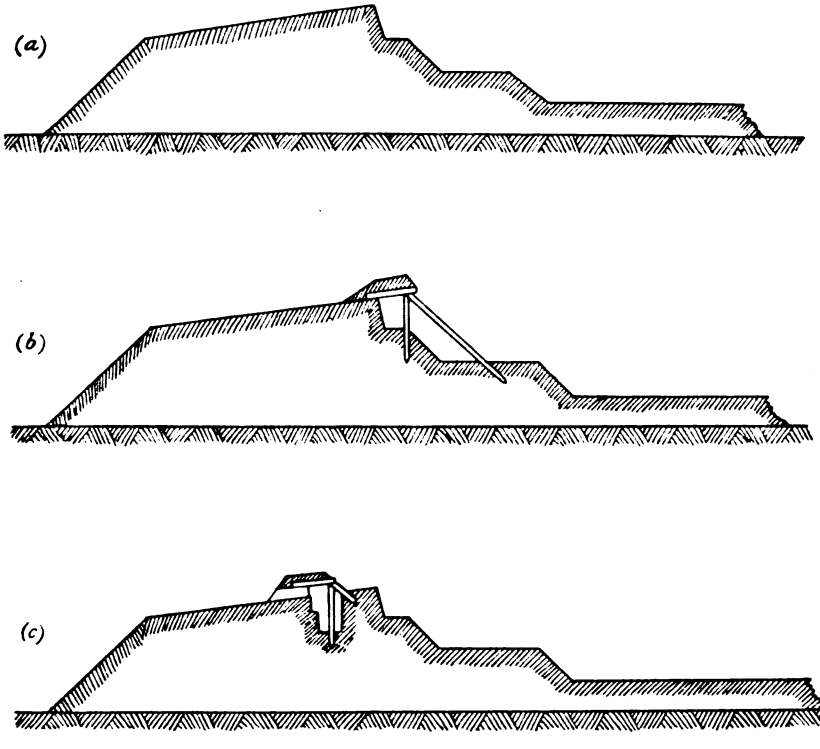
REVIEW.

VON BRUNNER'S PERMANENT FORTIFICATION.

(Translated by Capt. R. WALKER, R.E.).

THIS book, having been recently translated, is now accessible to all R.E. officers, and while all will concur in the general excellence of the work, they will discover during its perusal small problems, the solution of which will be rendered easier by discussion.

The sections of the works given in the plates present one of them. It will be noticed that none of the sections given are suitable for the establishment of overhead cover for the infantry firing line. The general type of parapet shown is that below :—



(*a*), shows the parapet without overhead cover.

(*b*), shows the difficulty of establishing overhead cover, the abnormal length necessary for the raking strut rendering it practically impossible to do so.

(*c*), shows an alternative method of establishing overhead cover in an old-fashioned parapet.

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The author disposes of the matter in the following words* :—"The whole infantry position might be made of concrete, and shields might be provided as a protection againt artillery fire, but the expense would be prohibitive. Overhead cover against shrapnel bullets and shell splinters for the infantry manning the parapet might be provided, but any such light protection will be completely destroyed during the bombardment which often lasts for many weeks." Now this statement, particularly the latter portion of it, "any such light protection would be completely destroyed during the bombardment which often lasts for many weeks," may be true of the Continent, but is it true of the land fronts of British and Colonial fortresses? Certainly not, that is, if the fortresses on the frontier of India be omitted from consideration. If the land front of a British or Colonial fortress had to undergo a bombardment of many weeks, it would have lost its *raison d'être*, for such a prolonged siege implies a loss of sea command which would in itself render any resistance on the part of the fortress useless. In all probability Great Britain would have been forced to submit to a humiliating peace even before the heavy guns of the besieger could have been placed in position.

From the foregoing considerations we arrive at a conclusion which clearly shows why in small details British should differ from Continental practice. Another case in which this occurs may be mentioned here. As our fortresses are unlikely to be exposed to a prolonged bombardment, armoured casemates and cupolas are unnecessary for the heavier types of howitzers and flat trajectory guns. Armoured cupolas and emplacements however should be provided for the lighter Q.F. and machine guns which are employed for flanking obstacles or for sweeping the intervals between the forts, otherwise a concentrated shrapnel fire from field guns and such siege guns as may be landed, aimed at those sited at critical points, might render it impossible to serve them when the moment for such action arrived.

In conclusion one small criticism of an otherwise excellent translation may perhaps be made. On page 40 of the translation, page 58 of the original the words "Traditor Casemate" occur. What are these "Traditor Casemates"? They are nothing but orillons brought up to date, and why not call them therefore orillons, or perhaps, better still, retired flanks, and avoid adding another expression to those already forming the jargon of a somewhat technical art, a jargon that it is as well to avoid if we wish to be read by the layman or even by the infantry soldier, whose business, amongst others, it may be to defend any land fronts that we may erect.

H. E. G. CLAYTON.

* Page 35 of translation, page 49 of original.

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NOTICES OF MAGAZINES.

Memorial de Ingenieros.

April, 1911.

The Administration of the *Memorial de Ingenieros* is to be congratulated on the excellent number (containing 280 pages), which it has published in commemoration of the 200th anniversary of the foundation of the Corps of Engineers in Spain.

The number opens with a dedicatory note from the pen of General Don José Marvá in which he briefly sketches the history of the corps from its initiation on the 21st April, 1711, to the present day, and mentions a few of the distinguished names that have adorned its history. Its motto is Onward! ever Onward! and if a halt is made to cast a glance back over the past, it is only with the object of gaining a fresh stimulus to push on towards the future.

Biographies are given of ten notable engineer officers. Of these the most interesting to an Englishman is that of General Verboom, the founder of the corps. This distinguished officer was born at Antwerp in the year 1665, son of Cornelius Verboom, Chief Engineer of the Spanish forces in the Low Countries. His military career commenced in 1674, when at the age of 9 he took part with his father in the defence of Besançon and Dôle. On the 5th February, 1677, he was appointed an Infantry Cadet and in 1684 Volunteer Engineer. In 1691 he was present at the Siege of Mons, fighting under King William III. against the French.

In 1693 on the death of his father Verboom was appointed to succeed him as Chief Engineer, though his army rank was only that of captain of infantry, and two years later he assisted the celebrated Dutch general, Coehoorn, at the Siege of Namur.

After the Peace of Ryswych, signed on the 28th September, 1697, Dutch garrisons were placed in the so-called barrier fortresses of the Low Countries, and consequently the duties of the Spanish Chief Engineer were much lightened, and Verboom, though still retaining that title, was promoted colonel of the Lorraine Regiment of cavalry in 1698.

The death of Charles II. of Spain in 1700 completely changed the European situation, and from that date onwards Verboom, who had previously fought three campaigns on the side of the English, found himself during the remainder of his long life constantly fighting against them.

As the King left no direct heirs, the succession to the throne of Spain was disputed by the Houses of France and Austria. Louis XIV. supported the candidature of his grandson, the Duc d'Anjou, and Maximilian,

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Elector of Bavaria, who was at that time Regent of the Spanish Netherlands, proclaimed him in Brussels under the name of Phillip V. The Austrian candidate was the Archduke Charles, son of the Emperor Leopold I., and amongst his supporters were England and Holland, the bitter enemies of the French King.

Verboom's first duty was to reorganize the defences of Antwerp, and to this end he built the forts of Dam and Austruweel, with numerous batteries, threw a bridge across the Scheldt, and projected a bridgehead on the left bank of that river. On the 8th February, 1702, he was promoted brigadier-general and two months later he was serving under Vauban at the Siege of Hulst. Shortly afterwards he was in Antwerp when that place capitulated to Lord Cadogan.

During the campaign of 1706 Verboom gained high praise for his relief of Termonde which was being besieged by the Duke of Marlborough, but for some unknown reason, he was arrested shortly afterwards and confined in the Citadel of Valenciennes. He did not, however, long remain a prisoner.

All Phillip's hopes of retaining the Low Countries were dashed to the ground by the defeat of the French Army at Ramillies, and those of his Belgian officers who did not transfer their allegiance to the Archduke, retired to Spain. Amongst them was Verboom, who arrived in Madrid early in 1709. He was at once entrusted with the organization of a Corps of Engineers in the Spanish Army, but as he was ordered to join the troops that were operating on the Portuguese frontier his work was much delayed. On the 18th December of this year he was promoted lieutenant-general, and on the 13th of the following January appointed Engineer General and Quartermaster-General of the Royal armies.

The first Spanish engineer of whom there is any record is D. Pedro Navarro who served in the armies of Ferdinand and Isabella at the end of the 15th and beginning of the 16th centuries. Charles V. employed many Italian engineers, and Phillip II. devoted special attention to engineering matters. The latter monarch acted as his own Chief Engineer, conducted direct correspondence with the engineers charged with carrying out various important works in fortresses, examined their projects and gave them instructions thereon. During the reigns of Phillip III. and Phillip IV. the number of engineers diminished, and during the period of penury which prevailed during the reign of Charles II. the engineer service practically disappeared. Verboom had consequently great difficulties to contend with in organizing a Corps of Engineers, as there were no trained officers in Spain to form the nucleus of the corps. He had therefore to endeavour to obtain from Flanders some of the engineers who had there served under his orders.

On his return from Portugal, he was given but a short rest, and in May, 1710, accompanied the King to Lérida where the army of the Marques de Villadarias was engaged with the Archduke's forces under Count Staremberg. The result of this campaign was disastrous, for on the 27th July Phillip's army was routed at the Battle of Almenara, and Verboom himself was taken prisoner, and confined in Barcelona where he remained until exchanged in March, 1712.

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The time spent in prison was not, however, wasted, as he appears to have enjoyed a great deal of liberty and was able not merely to complete his scheme for the organization of the corps but also to reconnoitre the Austrian defences, thus obtaining information which proved invaluable when in 1714 he found himself Chief Engineer of the army which was laying siege to Barcelona. That city was captured on the 13th September of that year by the Duke of Berwick exactly three months after the opening of the trenches, his success being largely due to Verboom's engineering talents.

Verboom's scheme for the organization of a Corps of Engineers was approved by a Royal decree of the 21st April, 1711. It provided for an Engineer General, one Engineer Director for each province, and an establishment of second and third engineers to whom was to be assigned the equivalent army rank of lieutenant-colonel, captain and lieutenant respectively. In making the latter recommendation Verboom remarked that "there was no reason why this class of officer who worked more and was more exposed to the dangers of war than any other should be" deprived of army rank. In war time brigades of from 8 to 10 engineer officers were to be formed under a Chief Engineer assisted by a sub-chief and an adjutant.

In May, 1718, Verboom was appointed Governor of the Citadel of Barcelona, a post which he held for the remaining 26 years of his long life. He was not, however, permitted to remain there in idleness, for in the same year he took part in the expedition to Sicily and was Engineer-in-Chief of the Spanish Army at the capture of the fortress of Palermo and Messina.

In the autumn of 1719 he returned to Spain, to find a fresh change in the kaleidoscope of European politics. Louis XIV. had died four years earlier, and the jealousy which had been smouldering for some time between the Regent Orleans and Phillip V. soon broke into flame. France entered into an alliance with England and Austria and invaded the Peninsula along the roads at both ends of the Pyrenees. The eastern army occupied Seo de Urgel, and Verboom's first task on returning from Sicily, was to assist in laying siege to that fortress. Trenches were opened on the 22nd January, 1720, and on the 29th of the same month the place surrendered. Verboom was appointed Governor of the fortress and lost no time in commencing the reconstruction of its defences. Peace was signed at The Hague on the 17th February, 1720, and Verboom then found time to propose various improvements in the organization of the engineer corps.

His plans were approved, and the establishment was fixed at 1 Engineer General, 9 Engineer Directors, 9 Chief Engineers, 27 Second Engineers, 42 Ordinary Engineers, and 40 Extraordinary Engineers. Engineers Commands were established in the provinces of Andalusia, Extremadura, Castille and Asturias, Galicia, Navarre, Guipuzcoa and Vizcaya; Aragon, Valencia and Murcia; Granada and the possessions in the north of Africa; and Catalonia. A Military Mathematical Academy was also founded in Barcelona under the inspectorship of the Engineer-General.

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From 1721 to 1727 Verboom was constantly engaged on tours of inspection, Pamplona, Alicante, Murcia, Malaga, Ceuta, Cadiz and Seville being visited in turn and important works undertaken at each of them. In 1726 Verboom was called to Madrid to advise on the proposed siege of Gibraltar. In January, 1727, he was created Vizconde de Nieuvorde and Marqués de Verboom, and in the same month he joined the army of the Count de Torres before Gibraltar. This army consisted of 30 battalions of infantry, 6 companies of carabineros, 900 cavalry and a siege train of 100 guns with many mortars and 4,000 quintals of powder. The siege commenced by an assault on the Devil's Tower, but the attackers suffered such heavy losses that they were compelled to withdraw, and renewed their attack on the other side of the isthmus. Verboom, at a council of war, held at the end of January, expressed the opinion that any attack on the Rock was doomed to failure unless made in co-operation with a strong naval force, which was not at that time available for the Spaniards. The differences between himself and the Commander-in-Chief became so acute that he was shortly afterwards recalled to Madrid where he remained till the beginning of 1731, occupied amongst other things in preparing plans for the defence of Cuba, Montevideo and Buenos Aires.

In 1737 Verboom was promoted Captain-General, and died in his quarters at the Citadel of Barcelona on the 19th January, 1744, after 70 years of service during which he had taken part in no fewer than 28 campaigns. He was buried in the Church of Saint Catherine, now demolished.

His two sons were both engineer officers, the elder predeceased him by 11 years, and the younger only survived him by a few months.

The most interesting of the remaining biographies is that of General Zarco del Valle who fought throughout the Peninsular War and played a most distinguished part in the reign of Isabella II.

The number closes with a complete list of all other officers of the Corps from its foundation in 1711 to the present time, and also with list of the names, as far as they are known, of the engineers who served in the Spanish Army during the 15th, 16th and 17th centuries.

'M.'

RIVISTA TECNICA DI AERONAUTICA.

July to December, 1910.

There is an interesting account of a voyage of the Italian military airship No. 2 from Bracciano to Campalto from 29th September to 2nd October. This airship has a cubic capacity of about 150,000 cub. ft., a 100-H.P. motor and carries fuel for 20 hours. The car is a real boat suitable for navigation on water.

The envelope is different from former types, being somewhat rounded

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at the stern, and is divided into eight compartments. The material is different being an experimental rubbered fabric, not covered with aluminium powder.

The speed is about 50 k.m. per hour. The voyage was full of incident.

Near Chiusi a stoppage was caused by the motor heating, the defect being soon put right. At Arerro after five hours' journey a forced landing was made, with the motor stopped owing to a propeller catching in the suspension and being broken. Fortunately the motor was at once stopped or the envelope might have been torn, and a disaster have occurred.

The landing place was inconvenient being heavily wooded, but fortunately a number of peasants were available who saved the ship bumping and took her off to a sheltered spot, where repairs were carried out.

At 9.30 on the 30th the ship started again for Venice and crossed the Apennines without difficulty, though all the ballast and some of the fuel had to be jettisoned, and a descent made for fresh supplies of hydrogen and fuel near Sant' Arcangelo.

A fresh start was made at 12.15 on October 1st. but near Porto Caleri towards evening the slackness of the envelope, due to cold and loss of hydrogen, suggested a further stop.

The last stage (40 k.m.) to Venice was effected on the morning of October 2nd, and she was safely housed in her shed at Campalto.

There is a useful mathematical investigation of the pressure on the supporting surfaces of an aeroplane.

There is a short account of the progress of "aerostation" in Italy in 1910. It has not progressed much in 1909, in which it differs from "aviation," which has made very rapid progress. Important work has, however, been carried out, the military airships have made many useful journeys, a great impetus has been given to the sport of spherical ballooning, and Engineer Forlanini and Count Almerigo da Schio have improved their airships.

At the International Congress held at Verona in May, the following general propositions met with approval, and show in what form we may expect the international character of the air to be treated :—

1. That the atmosphere over the land and territorial waters of every state should be considered as territorial atmosphere subject to the sovereignty of each particular state. Atmosphere over unoccupied lands or free waters should be considered as free.
2. That within territorial atmosphere, the journeys of aerial vessels should be free, subject to such control as is necessary to safeguard public and private interests, and subject to the laws of the nation to which the vessel belongs.
3. That journeys of aerial vessels in free atmosphere, ought, in all important respects, to be regulated by international rules.

Many interesting papers were read at this conference.

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The Italian Touring Club has instituted a National Commission of Aerial Touring which has taken up the question of maps for aerial pilots, and that of pilots and control of licenses.

The latter is recognized to be now of great importance. The F.A.I. deals satisfactorily with all members of aero clubs, but has no control over those who are not members, who may be quite unskilled, whose machines may be badly designed and constructed, and yet are able to take up passengers and generally endanger the public.

Laws are necessary on the subject.

A new airship under construction by the Airship Co. "Veeh" at Monaco, is expected shortly to make its *début*. It is a large ship on a new system.

The envelope is about 100 m. long and 16 m. in diameter with a capacity of 13,030 c.m. (about 455,000 cub. ft.). It is constructed of a new material metalled on either side, which renders it waterproof and also prevents the sun's rays affecting the interior gas. The total height of the ship is 25 m. and it has an overall breadth of 18 m.

All the framework is of steel tubing. The car has two towers which extend into the envelope and carries two horizontal screws for raising or lowering the ship vertically.

In all there are eight screws operated by four motors viz.: two 200-H P. "Wodan" and two 150-H.P. of the same make. They are said to weigh 2 k.g. per H.P. and to be entirely reliable. The anticipated speed is not given, but with this large H.P. is expected to be high.

The ship is to carry 40 passengers, but the length of journey with this load is not stated.

This Review would appear to be badly supported as the months from July to December, 1910, inclusive make only one part of the usual monthly size.

J. E. CAPPER

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CORRESPONDENCE.

THE "DRIFT" OF A BULLET.

DEAR SIR,

Colonel de Villamil's paper on "Drift" in the March number of *R.E. Journal*, p. 318, line 13 from bottom, says "the point turns out of the plane of the paper and towards the spectator." I am afraid the opposite is the case, as can be verified from any book dealing with rotational dynamics. All photographs of rotating bullets in air show that "the point of the bullet is above the line of the trajectory."

Professor J. B. Henderson, D.SC., in his "Flight of a Rifle Projectile in Air," *Proceedings of the Royal Society A.*, Vol. 82, 1909, shows the gyroscopic action which takes place, and so explains drift and other phenomena of a projectile in air.

Professor Magnus, Berlin, carried out, some 50 years ago, a series of experiments on spherical and elongated projectiles, and he proved that an ogival-headed projectile drifts to the right (with right-handed twist of rotation) provided the point of the projectile be a trifle above the line of the trajectory. Photographs show that this is the case.

CGD being the direction of motion of G, the centre of gravity of the projectile, GAB its axis, the resultant resistance of the air tends to turn the projectile about an axis through G, perpendicular to the plane BGD, in the direction shown by the arrows. If the shot had no rotation, it would fly end over end. But when the shot seen from C has a right-handed rotation about its axis, this motion combined with that which the resistance of the air imparts to the shot deflects the point A as seen from C to the right. In consequence of this deflection of the point A to the right, the resistance of the air acting on the left-hand-side surface of the ogival-headed projectile creates a couple about G whose axis is vertical and right-handed, when looking downwards from C: this couple then, when combined with the rotation of the projectile turns the axis GA of the shot downwards, that is towards the tangent to the trajectory.

C. E. PHIPPS,
Major, R.A.

The Editor, *R.E. Journal.*

SIR,

I have to thank Capt. Edgeworth for pointing out a foolish mistake I have fallen into. Always repeating an experiment in the same manner, coupled with the impression, apparently shared with Capt. Carey, that it

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had been found that the bullet drifted "in the wrong direction to suit this theory," is the probable reason for this: though that is no real excuse and I can only apologize for making the statement I did. My line of argument is not materially altered by the change—except that everything must be reversed, "right" for "left," "up" for "down," and so on—the essential being that the gyroscopic action turns the point of the bullet to the left of the trajectory, and that the horizontal component of the resulting resistance, in "hurrying up the precession," forces the point of the bullet vertically towards the line of the trajectory. There is no necessity, of course, to make any assumption that the point of the bullet is *below* the trajectory.

Possibly this is what the writer of the Textbook meant. If so I also am an "uncompromising supporter" of this theory, though I think that the wording of the description leaves much to be desired. Personally I am more interested in the resistance than in the "drift."

I am afraid I cannot agree that Capt. Carey's explanation of a bullet rolling on the air is very simple. The coefficient of viscosity μ is "independent of the density," (Stokes) so the bullet could get no more "grip" on the air if the latter were much compressed.

With regard to C. S. Jackson's letter—no excuse necessary for being a mere student: before Nature we are all students, and poor things at that—there are doubtless many formulæ of the type proposed by me. Newton, Coulomb, Dr. Young and Girard (to name only a few of the most eminent men) employed similar formulæ.

The formula offered by me is intended to include all possible motions of the air. A is the coefficient for all direct motion, B for sinuous motion (eddies, vortices, etc.) and C for all motion due to compression of the air. "Air carried with the bullet" would come under A, which varies as the length of the bullet and as its diameter.

"Potential energy" is a convenient expression which I employed in the sense used by Lord Rayleigh in the formula

$$Po = p + \tfrac{1}{2}\rho v^2$$

where p = potential energy, or pressure and $\frac{1}{2}\rho v^2$ the kinetic energy, per unit of volume, in all parts of a stream line (*Hydrodynamics*, 1876). When $p = o$, I expressed it as being "exhausted." The bullet "still generates waves," of course, but the kinetic energy generated, per unit of time *remains constant.*

Yours faithfully,

May 8th, 1911. R. DE VILLAMIL.

P.S.—Since writing the above I have been allowed to see a copy of Major Phipps' letter and I thoroughly agree that the explanation given at the end of it appears a correct statement of what takes place, ordinarily. It is, of course, only a good *first approximation;* for the point of the projectile must be describing some sort of a curve (? spiral) and this would tend to cause other minor movements.

May 9th, 1911.

The Editor, *R.E. Journal.*

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RECENT PUBLICATIONS OF MILITARY INTEREST.

APRIL, 1911.

(*Published Quarterly*).

THE following extracts from the list compiled by the General Staff, War Office, are published in the *R.E. Journal* by permission of the Army Council.

*PART II.**

SECTION I.

AERIAL NAVIGATION.

THE CONSTRUCTION OF AIRSHIP SHEDS (Luftschiffhallenbau). By Haenig. 170 pp., with numerous diagrams. 8vo. Rostock, 1910. Volckmann. 6s. 6d.

This book, which is written by an engineer, discusses in detail the various systems of construction of airship sheds.

MEANS OF COMMUNICATION IN WAR (Die Verkehrsmittel im Kriege). By Schmiedecke. 363 pp., with numerous maps and diagrams. 8vo. Berlin, 1911. Mittler. 7s. 6d.

This is the second edition of a book originally published in 1905. It has been brought up to date, and a special chapter has been devoted to airships.

BOOKS OF REFERENCE.

THE ARMY ANNUAL AND YEAR BOOK, 1910. By Major B. F. S. Baden-Powell and Lieut.-Colonel H. M. E. Brunker. 384 pp. 8vo. London, 1910. W. Clowes. 7s. 6d.

This volume forms a fairly complete book of reference on matters connected with the Forces of the Crown for 1909 and the first six months of 1910.

Amongst others, the book contains the following articles:—

Military defence of the Empire and the Imperial General Staff.
Discipline in the army.
The military forces of the Crown which includes Lord Kitchener's recommendations for the organization of the forces of Australia and New Zealand.
The boy scouts.
The army manœuvres in England, 1909.
The training of the Cavalry Division in England in 1909.
Military inventions of the year.

In their preface the authors very briefly summarize the chief events and changes of the year. They conclude by hoping that "readers will offer any suggestions which they think will tend to make the *Army Annual* a thoroughly useful and reliable work of reference on military matters."

* The titles of all books are given in English; this does not indicate that the books have been translated. The original title in the language in which a work is written, if not in English, is given in brackets.

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CAVALRY.

PART I. CAVALRY TACTICS AS ILLUSTRATED BY THE WAR OF THE REBELLION. By Capt. Alonzo Gray, 14th U.S. Cavalry. 187 pp. 8vo. Fort Leavenworth, Kansas, 1910. U.S. Cavalry Association. 5s. 9d.

At first sight this book may appear dry reading—comprising as it does a number of tabulated extracts from official reports and despatches with marginal notes. When gone into, however, it is most interesting. The author has collected a large number of examples from the American Civil War to illustrate various points connected with the armament, leading tactics, equipment, etc., of cavalry in the field. Each point is dealt with separately, and at the end of the extracts he has collected the author gives his own comments.

The book is worth study by officers of mounted corps.

FORTIFICATION AND MILITARY ENGINEERING.

INSTRUCTIONS FOR THE ATTACK AND DEFENCE OF FORTRESSES (Anleitung für den Kamp um Festungen). Official. 95 pp., with 2 sketches. 12mo. Berlin, 1910. Mittler. 10d.

These instructions have been issued to enable officers to study the principles of fortress warfare, and to ensure that the troops are thoroughly trained in peace in the duties required of them in war in the attack and defence of fortresses.

In the short introduction to the book, it is stated that commanders must always bear in mind that a spirit of bold offensive is the best guarantee for success, not only in the attack, but also in the defence.

The first portion of the *Instructions* deals with the attack of the fortress. Here the absolute necessity for the most intimate co-operation of all arms is mentioned again and again. It is pointed out that the infantry is incapable of making any progress or of reaching the final stages of the attack without the closest support of the artillery, and that, in the final stages, the assistance of the engineers alone will render it possible for the infantry to gain a footing in the enemy's final position.

As regards the artillery, care is to be taken that the guns of the attack do not engage in battle unless they are superior in number and calibre to those of the enemy and have sufficient ammunition to carry on the contest.

In the second portion of the book, which deals with the defence of fortresses, the *Instructions* show how advanced positions are likely to play a more important *rôle* than hitherto. The increased range of modern guns will enable the defender to offer a more protracted resistance in his advanced positions, provided the latter are situated within effective range of his main position.

The final decision, according to the *Instructions*, is to be sought for in the defender's main position, in contra-distinction to the French *Instructions* which state that, in the final stages, the troops should retire from their main position, and should await the assault in a position still further back called "la position de soutien."

Both in the attack and in the defence the German *Instructions* deal fully with the latest developments of technique likely to be of special importance in fortress warfare, such as wireless telegraphy, airships, aeroplanes, motors, etc.

SIEGE WARFARE (La Guerra d'Assedio). By Lieut.-Colonel Sachero. 162 pp. 8vo. Turin, 1909. Olivero. 4s.

This study of siege warfare is an epitome of the lectures delivered by Colonel Sachero on this subject at the Italian Staff College. The book is divided into three parts. Part I. is historical, and traces the development of all classes of fortification from the beginning of the century to the Siege of Port Arthur. In Part II. the offensive and defensive weapons used in siege warfare are discussed from a technical point of view. In Part III. the sytematic progress of a siege is discussed clearly and in considerable detail. An appendix contains a useful list of the latest works on the subject in French, German and Italian.

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HISTORICAL.

OFFICIAL HISTORY (NAVAL AND MILITARY) OF THE RUSSO-JAPANESE WAR. Vol. I. To the 24th August, 1904. Prepared by the Historical Section of the Committee of Imperial Defence. 566 pp., with 20 plates in the text and case of 18 charts and strategical maps. 8vo. London, 1910. His Majesty's Stationery Office. 15s.

This volume contains an account of the Russo-Japanese War from the opening of hostilities until the end of the first general attack upon Port Arthur on the 24th August, 1904. It deals with both the sea and the land operations. The account is to be completed in two further volumes.

The narrative of the land operations has already appeared in Parts 1, 2 and 3 of the *Official History of the Russo-Japanese War* issued by the Committee of Imperial Defence. The chapters of this work are now reprinted interspersed with naval chapters. Some new material has been added to them, notably the instructions given by General Kuropatkin to General Stoessel with regard to the general line of conduct to be followed by the garrison of the Kuan-tung Peninsula in case of a Japanese landing, and the latter commander's instructions to his subordinates based on them. Panoramas of the Ya-lu, Nan Shan and the Mo-tien Ling have also been added. There has been a slight rearrangement of the original chapters. Nan Shan has now a chapter to itself, instead of being included in the chapter on the landing of the Second Japanese Army; whilst "The Defences of Port Arthur" and "The Capture of Ta-ku Shan and Hsiao-ku Shan," which were separate chapters, now form one.

The chief interest in the volume is therefore naval. Whereas, however, the original military work was purely a narrative of events, the present combined account contains one chapter of 14 pages of "Naval Comments," followed by one of 23 pages of "Military Comments." In these the connection between the sea operations and the land operations is brought out.

The naval narrative is clearly and simply written, and is well illustrated by charts and black and white pictures of the actions. The only expression used which is not likely to be at once understood by landsmen is "blockship" or "block ship" (both versions appear in the book), to mean a vessel used for blocking a harbour entrance.

It is well in these days to be reminded again of the hazardous and uncertain nature of naval war as compared with war on land. In less than an hour's fighting on the 10th August, the after turrets of both the *Mikasa* and the *Asahi* became "silent and the *Shikishima* had one of her foremost 12" guns out of action, reducing the primary armament of the (Japanese) battleships from 16 to 11 guns." At the end of an hour's hard fighting when neither fleet had gained any real advantage, "a lucky shot," as the account truly calls it, killed the Russian Admiral, nearly brought down the foremast of the flagship and in some way interfered with its helm, causing uncertainty and confusion in the fleet, of which the Japanese took advantage. This "lucky shot" was the direct cause of the dispersal of the Russians. Nothing in any way similar could occur in land warfare, except, perhaps, during a night attack, or to a cavalry brigade, were the general commanding and staff suddenly wiped out when the squadrons had been brought within a decisive radius of the enemy's horsemen. In reading the naval narrative one is in fact constantly reminded of the similarities between the action of a fleet and that of a cavalry division manœuvring on a perfectly level plain without chance of concealment or hope of mystifying the enemy.

The most serious misfortune, however, happened to the Japanese fleet when it was, to use military language, within its own lines. On the 15th May two of the six first-class battleships, the *Hatsuse* and the *Yashima*, whilst on blockading duty off Port Arthur, struck mechanical mines and sank. Admiral Nashiba, who was on the former ship, transferred his flag to the despatch vessel the *Tatsuda*, but this vessel went ashore the same evening on one of the Elliot Islands and remained there for a month. "In the early hours of the same day, the Japanese fleet had sustained yet another loss, not on this occasion due to any act of the enemy." The second-class cruiser *Yoshino* was rammed in a thick fog by the *Kasuga* and sank in deep water, only 90 of her crew being saved. "Even this was not the last of the Japanese misfortunes," for on the night

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of the 17th May the destroyer *Akatsuki* struck a mine and sank immediately. "Thus, in the course of little more than three days, the Japanese Navy had been deprived of two battleships, a second-class cruiser, a destroyer and a gunboat," without having even a Russian dinghey to show on the profit side. As a great critic has pointed out, the lesson for England "is the frightful risk and overmastering anxiety which arise from the maintenance of an inadequate margin of naval strength." Henceforward aggressive tactics on the part of Admiral Togo became impossible.

The chapter of "Naval Comments" is practically wholly devoted to strategy. The only other topic treated in it is the influence of recent inventions. A page and a-half are given to illustrating the extraordinary value of submarine mines. They are stated, in addition to the material damage they actually occasioned, to "have proved most useful in delaying the movements of the (Japanese) enemy and in preventing co-operation between his army and navy," and later to have been "a source of great anxiety to the Japanese." The five 10" guns in the Electric Cliff Battery were "sufficiently formidable to keep the Japanese fleet at a distance of over seven miles." "The value of a few modern guns of high power mounted on shore was thus very clearly proved." It is further stated that "the risks are so great that a fleet will seldom be justified in engaging permanent works." Compared with the submarine mine and the gun, the torpedo "proved a somewhat ineffective weapon." "On the nights of the 23rd June and the 10th August, although a large number of attacks were made under conditions which might be considered favourable to the assailants, and many torpedoes were fired, not a single Russian ship was struck."

In dealing with naval strategy, it is pointed out that "the maintenance of Russian supremacy in Manchuria was only indirectly dependent upon the fleet, since there was a complete line of land communication from St. Petersburg to Port Arthur." On the other hand the island power "Japan was so placed that defeat at sea would have been disastrous, while victory, however complete, was no more than a supremely important step towards the defeat of the Russian Army." It is clear that, as has been said of defensive warfare, naval victories may prolong the agony but they cannot win a war.

It is admitted that Togo's "true *rôle* was in its essence defensive." "From first to last the Japanese naval commanders never forgot that their first duty was to guard the oversea communications of the army." He is praised for his self-restraint and perseverance in sticking to his plan of confining his enemy to Port Arthur and declining, after the heavy losses from accident that the Japanese fleet had sustained in May, to risk his "precious battleships." It is, however, laid down that "It is a cardinal rule of warfare that once battle is accepted no effort should be spared to make the result decisive." "It is conceivable that had Admiral Togo (on the 10th August in the Battle of the Yellow Sea) closed to effective range at the outset, the victory would have been as complete as that of the Sea of Japan a year later."

The chapter of "Military Comments," like that of "Naval Comments," is mainly strategical. Less than four pages are devoted to tactics and of these more than half relate to cavalry. The failure of the Russian cavalry is said to be "not difficult to account for . . . the country was most unsuitable for mounted action; large bodies could always be checked by well-posted infantry, and, at the same time, the Cossacks were practically untrained to act on foot, or in small bodies." The ineffectiveness of the Japanese cavalry is attributed to "faulty organization . . . more than three-quarters of the available mounted troops were tied to the infantry" (as divisional cavalry). As regards the other arms only two points are noticed at this point of the history:—the gradual conversion of the Russian artillery to indirect fire and the bold handling of the Japanese reserves.

It is stated that the "idea which underlay their (the Japanese) land strategy from the outset of the war" was the conviction "that Liao-yang was the point at which the first great battle against the Russian main army would be fought . . . and, true to their German teaching, they resolved that from the first their troops must be deployed in such a way as to enable them to envelop their enemy at Liao-yang."

It is, however, pointed out several pages later that the interest attaching to Port Arthur had a special effect on the strategy. "Be the result of the war what it might in other ways, on one point the mind of the Japanese people was made up, namely, that Port Arthur should become Japanese territory; and it was realized that when the time

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should come to make peace, it would greatly strengthen the hands of statesmen if the coveted fortress was already in the hands of soldiers and sailors." The problem which arose "as soon as the decision to pursue the double objective had been formed" is carefully examined. The dispersion it imposed is held to have been "to some extent obviated by the landing of the 10th Division at Ta-ku-shan, but still more by the skill with which numbers and intentions were concealed from the enemy."

In strong contrast to the Japanese, whose "diplomacy and strategy kept pace," the Russians are said to have been "completely unprepared. The inevitable result followed. The initiative in the conduct of operations was resigned to the enemy." Their strategy in holding on to Port Arthur is accounted to be correct, because the ships it contained were a constant menace to Japanese communications."

There are 100 pages of appendices. In addition to the military ones which have already appeared, there are naval appendices giving lists of Japanese and Russian war vessels and auxiliary vessels, and of the 67 "merchant vessels seized or sunk up to the 19th August, 1904"; the losses at the Battles of the Yellow Sea and Ulsan (as the fight in which the *Rurik* was lost is now called); and the damages sustained by Russian ships in these battles.

THE CAMPAIGN OF CHANCELLORSVILLE. A strategic and tactical study by John Bigelow, Jr., Major, U.S. Army (Retired). 528 pp., with 44 maps and plans. 4to. New Haven, 1909. Yale University Press. London, Henry Frowde. Oxford University Press. £2 10s.

This exhaustive work on the most dramatic campaign of the American Civil War is the result of a course of study undertaken by the author for the purpose of delivering a series of lectures at the Massachusetts Institute of Technology. He selected this campaign because it "presented a greater variety of military problems and experiences than any other in which an army of the United States has taken part. In no other was there so rapid a succession of critical situations. Moreover no other, approaching it in importance, has been so imperfectly apprehended and misunderstood." As a result of his studies he has produced a work, which, if not the last word on the subject, is far in advance of any earlier book.

DUPLEIX. By Colonel John Biddulph. 178 pp., with an appendix. 8vo. London, 1910. White. 5s.

A concise account of the life of an interesting and striking figure. The author has written without bias, and has presented a faithful and unexaggerated history of the career of the man who first brought India within the scope of European politics.

THE RUSSO-JAPANESE WAR, PART IV. (Der Japanisch-Russische Krieg, IV Teil). By General von Lignitz. 287 pp. (numbered 501–788). Table of contents; list of maps; list of authorities; 19 illustrations in text; 10 sketch maps; 2 sheets of plans; 23 appendices. 8vo. Berlin, 1911. Vossische Buchhandlung. 7s. 6d.

This volume deals with the Siege of Port Arthur from the middle of November, 1904, onward, and with the Battles of Heikoutai, Mukden and Tsushima, and the fighting in Saghalien. The sketch maps and plans show the front of attack at Port Arthur, the 203-metre height (from N.W. and S.E.), and Fort Sung-shu; the fighting at Mukden (several plans); the march of the Japanese 3rd Army (from Japanese sources) between the 26th February and the 10th March; the Malakov; Vladivostock; Harbin; Saghalien.

BUSSACO. By Lieut.-Colonel G. L. Chambers. 260 pp., with maps and illustrations. 8vo. London, 1910. Swan, Sonnenschein & Co. 7s. 6d.

The author briefly reviews the events leading to the battle, and deals in detail with the course of the battle itself. The special feature of the book is the careful study of the ground which it affords by means of a number of excellent photographs.

The description of the battle is put in an interesting way and is easy to follow.

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ORGANIZATION AND ADMINISTRATION.

THE MOTOR CAR AND THE ARMY (L'Automobile et l'Armée). By Capt. Vannier, 111th Infantry Regiment. 414 pp., with 60 illustrations and 3 maps. Paris, 1911. Chapelot. 8s.

This is a comprehensive and useful treatise on the military use of motor cars. After giving an account of the history and present position of the question in various foreign countries, of which Germany, England, Austria and Italy have made the greatest progress, the author describes in great detail the machine which the French War Office has purchased and the various trials and competitions for which Government prizes have been offered. He then discusses from the point of view of the French Army the future employment of motor lorries and considers that their use will permit of the suppression of the divisional cattle-park, three-quarters of the supply columns and parks, and one-half of the ammunition columns and parks. But since his calculations require for the French Army the use of 75 "Renard" trains, 4,000 motor lorries, 3,300 light motors and 600 motor-bicycles, it is evident that some years must still elapse before his plan can be brought into practice.

Chapter VI. contains a carefully worked out scheme for the supply of food, ammunition, stores, etc., to an army corps by motor transport, and since the general idea is the same as that in *Un Voyage d'Etat Major de Corps d'Armée*, published in 1908 by Chapelot, we have an interesting comparison between motor and horse transport.

The book will be useful to any officer desirous of studying the problem of motor transport and the administrative services of the French Army.

TRAINING AND EDUCATION.

STAFF RIDES. By Capt. Marindin, The Black Watch. 104 pp. 12 mo. London, 1910. Hugh Rees. 2s.

This is the fifth edition of a useful little book, which is now well known in the Service. The new edition was necessary in order to bring it into line with field service regulations. It is fairly complete and should prove a great help to officers responsible for the direction of staff rides—or staff tours as they are now called in Training and Manœuvre Regulations. The latter manual was not in existence when Capt. Marindin first brought out his book.

THE DEFENCE OF UNITED SOUTH AFRICA AS A PART OF THE BRITISH EMPIRE. Lectures by Brigadier-General G. G. Aston, C.B., with a Preface by General Lord Methuen. 63 pp. 16mo. London, 1910. Hugh Rees. 1s.

Under the above title are printed three lectures and an address by Brigadier-General G. G. Aston, together with a preface by General Lord Methuen, General Officer Commanding-in-Chief, South Africa.

MISCELLANEOUS.

THE PATHAN BORDERLAND. By C. M. Enriquez, 21st Punjabis. 141 pp., with a map and appendix. 8vo. Calcutta, 1910. Thacker. 6s.

An interesting little book, in which the author gives a good deal of useful general information concerning the frontier tribes who inhabit the districts adjacent to our Indian border-land, from Chitral to Dera Ismail Khan.

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RECENT DEVELOPMENTS IN THE DESIGN AND CONSTRUCTION OF EARTHEN DAMS

PLATE I.

FIG. 1.

General Cross Section for very High Embankment.

Scale—60 Feet = 1 Inch.

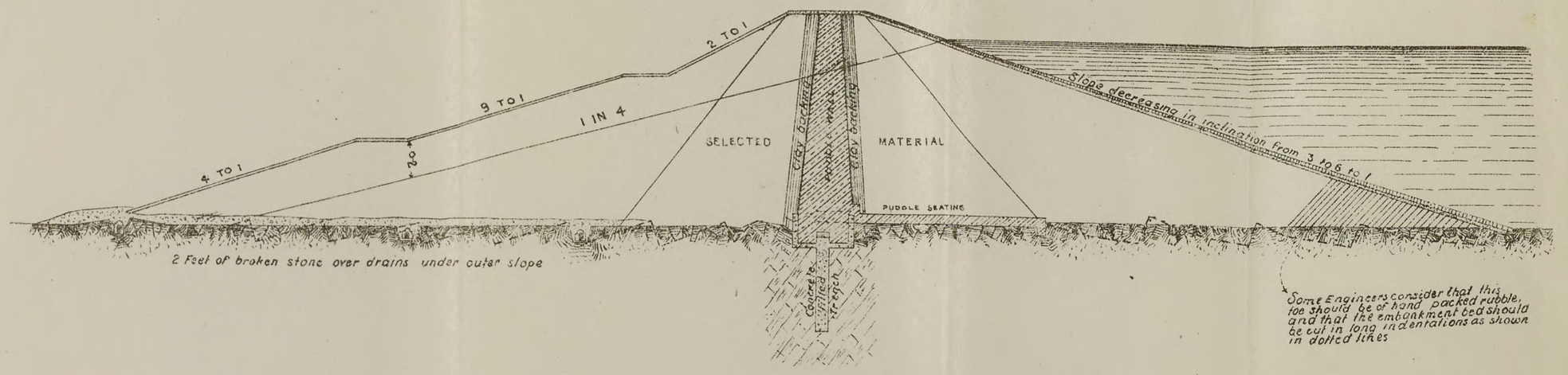
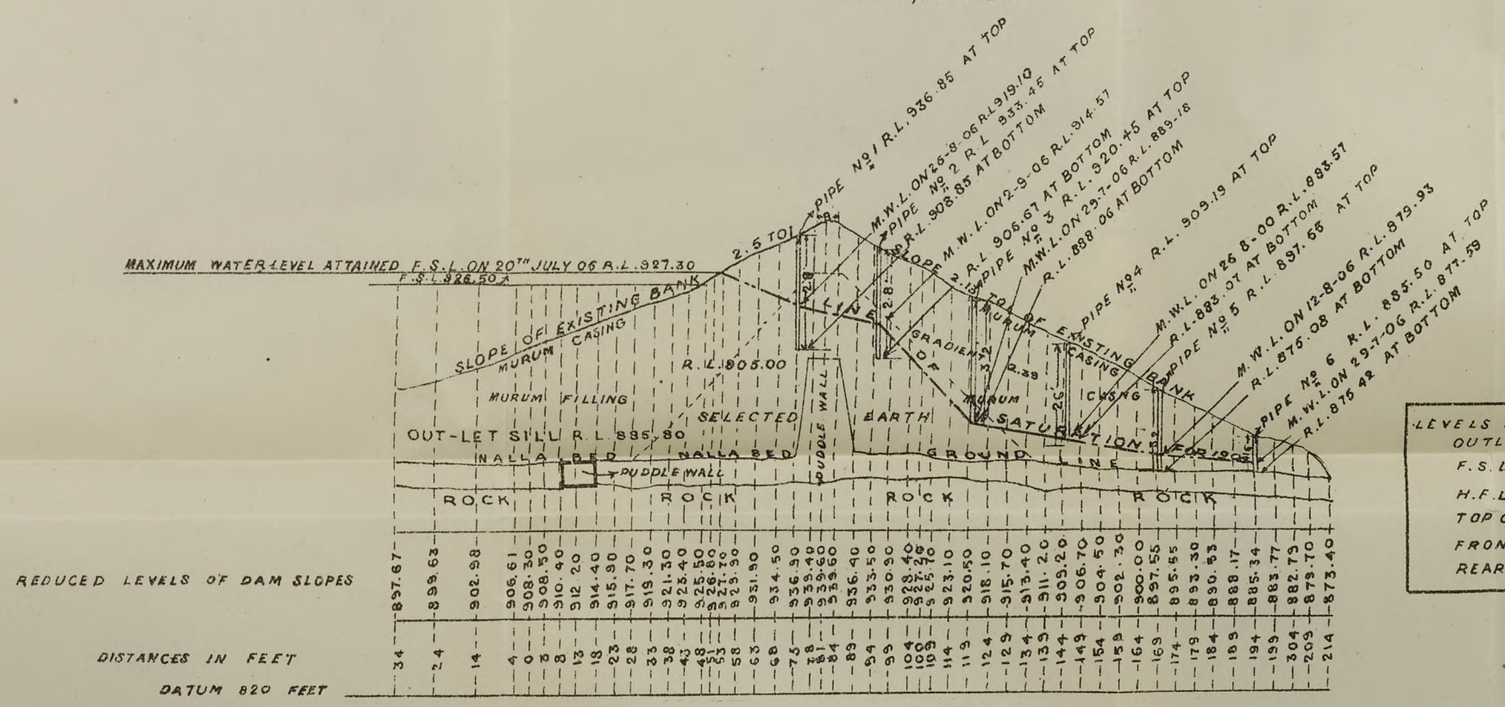

4 TO 1
9 TO 1
2 TO 1
1 IN 4
20'
SELECTED
MATERIAL
Clay backing
Puddle wall
Clay backing
PUDDLE SEATING
Concrete filled trench
Slope decreasing in inclination from 3 to 6 to 1
2 Feet of broken stone over drains under outer slope
Some Engineers consider that this toe should be of hand packed rubble, and that the embankment bed should be cut in long indentations as shown in dotted lines

FIG. 2.

Cross Section of Mukti Tank

Scale—40 Feet = 1 Inch.

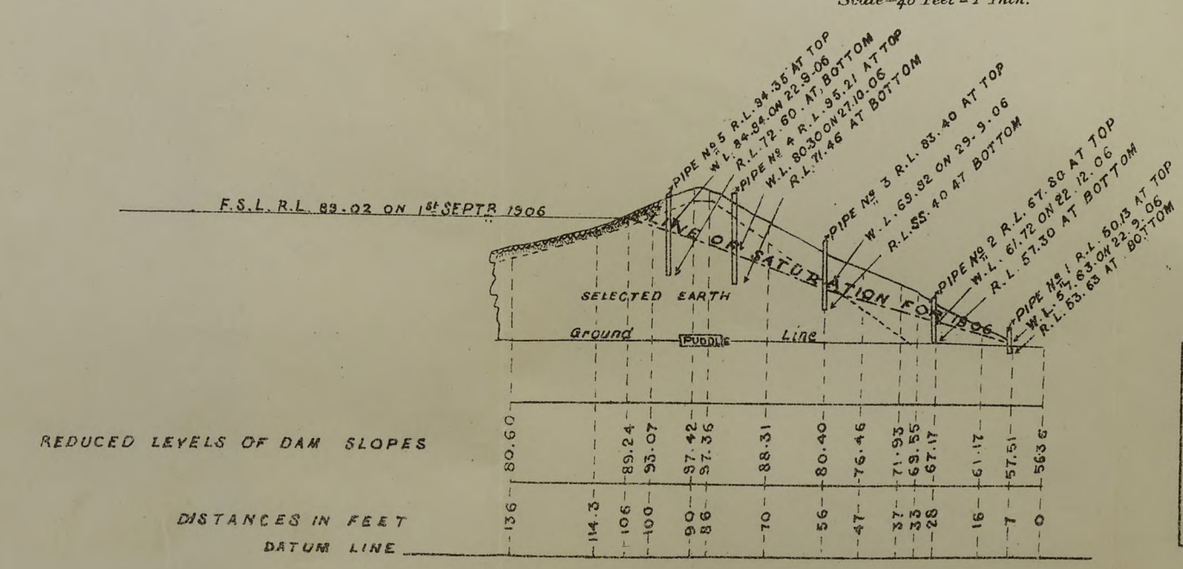


LEVELS AS PER SANCTIONED DESIGN	
OUTLET SILL	R.L 885.50
F.S.L.	R.L. 926.50
H.F.L.	R.L. 932.10
TOP OF DAM	R.L. 939.60
FRONT SLOPE	2½ TO 1
REAR SLOPE	2.13 TO 1

FIG. 3.

Cross Section of Matoba Tank.

Scale—40 Feet = 1 Inch.


F.S.L. R.L. 89.02 ON 1st SEPTR 1906
PIPE No 5 R.L. 94.36 AT TOP
W.L. 84.84 ON 22.9.06
R.L. 72.60 AT BOTTOM
PIPE No 4 R.L. 95.21 AT TOP
W.L. 80.30 ON 27.10.06
R.L. 71.46 AT BOTTOM
PIPE No 3 R.L. 83.40 AT TOP
W.L. 69.52 ON 29.9.06
R.L. 55.40 AT BOTTOM
PIPE No 2 R.L. 67.80 AT TOP
W.L. 61.72 ON 22.12.06
R.L. 57.30 AT BOTTOM
PIPE No 1 R.L. 60.13 AT TOP
W.L. 57.63 ON 22.9.06
R.L. 53.63 AT BOTTOM
LINE OF SATURATION FOR 1906
SELECTED EARTH
Ground Line
Puddle
REDUCED LEVELS OF DAM SLOPES
DISTANCES IN FEET
DATUM LINE
80.60 89.24 93.07 87.42 87.36 88.31 80.40 76.46 71.93 69.55 67.17 61.17 57.51 56.36
136 114.3 106 100 90 86 70 56 47 37 33 28 16 7 0

LEVELS AS PER SANCTIONED DESIGN	
OUT-LET SILL	R.L. 60.02
F.S.L.	R.L. 89.02
H.F.L.	R.L. 92.02
TOP OF DAM	R.L. 97.35
FRONT SLOPE	3 TO 1
REAR SLOPE	1½ TO 1

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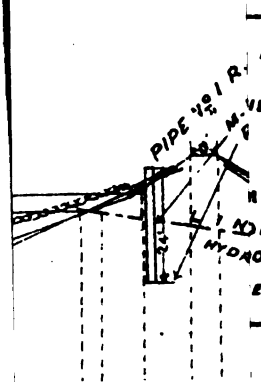
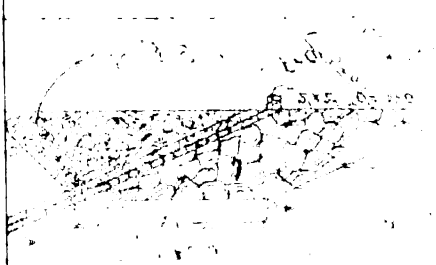
NTS IN THARTHEN DAMS

PLATE II.



PER SANCTIONED DESIGN

VLL R.L 1841.38
R.L. 1876.38
R.L 1879.38
R.L. 1886.38
OPE 3 TO 1 UP TO H.F.L
DAO 2 TO 1 ABOVE H.F.L.
E 2 TO 1 UP TO TOP OF DAM



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